Quality in Dry Wines

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The Vintage

THOS. SHIELDS CLARKE PARIS, 1892

GOLDEN GATE PARK

SAN FRANCISCO, CALIFORNIA

Quality in Dry Wines

through

Adequate Fermentations

BY MEANS OF DEFECATION, AERATION
PURE YEAST, COOLING AND HEATING

A MANUAL

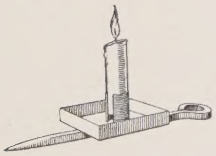
FOR

PROGRESSIVE WINEMAKERS
IN CALIFORNIA

BY

RUDOLF JORDAN, JR.

ILLUSTRATED



SAN FRANCISCO, CALIFORNIA

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TO THE MEMORY OF

MY FATHER,

A STURDY CALIFORNIA PIONEER OF 1849, WHO CONTRIBUTED HIS SHARE TOWARD THE DEVELOPMENT OF VITICULTURE IN THIS STATE, THIS LITTLE VOLUME IS GRATEFULLY DEDICATED.

"We are always in these days endeavoring to separate intellect and manual labor; we want one man to be always thinking and another to be always working, and we call one a gentleman and the other an operative; whereas the workman ought often to be thinking and the thinker often to be working, and both should be gentlemen in the best sense. As it is, we make both ungentle, the one envying, the other despising his brother; and the mass of society is made up of morbid thinkers and miserable workers."

—John Ruskin.

PREFACE

California offers possibilities by her soil and climate that will give her a world-wide reputation for the quality of her dry wines. With the hope that such a prospect may be realized in the near future by the best means at our command this manual was prepared for all who have the interests of this industry at heart. A closer attention to the details of fermentations forms the very foundation for the better quality of the product. Like the big wheatfields of former days, our vineyards and cellars are too often judged by the *quantity* rather than by the *quality* of their wines. With little encouragement from the winedealers, or socalled captains of the industry, the rank and file of our winemakers is compelled to make wine as cheaply as possible. It is held that the means and the skill of the former will rectify any errors of the latter. Whatever may be the merit of such a course from the standpoint of business profit, there seems to be evidence enough to prove that indifferently made wines and those that have been corrected have discredited the reputation of our state. A sounder policy should therefore prevail for the true progress of this industry, and every encouragement should be directed toward better methods of *making* the wine, so that it may be sound from the start.

Luck is still often taken to be a necessary part of winemaking, and the process has been considered beyond human control; but thanks to the unceasing investigations of the men of science we are now able to conduct winemaking with more certain results. We should follow their lead and in our own endeavors

for quality should be guided by the simple principle: *a little less mystery and a little more enlightenment.* We are never too old to learn, and it is never too late to mend our ways. While weather conditions, from the first budding of the vine to the gathering of the grapes, will always remain beyond our control, we have nowadays at least some definite knowledge for the control of wild or arbitrary fermentations.

The facts and observations here recorded have been presented in a more thorough and scientific manner by the competent men of our State University, notably by Mr. Frederic T. Bioletti, who has been very active in advocating better quality in wines and to whom the writer is indebted for much of his knowledge of the methods herein discussed. The cry has usually been that scientific men are as a rule too theoretical and are therefore unable to strike a general average for the conditions prevailing in a wine cellar. The scientist must work on a small and exact scale in his laboratory, but what holds true there is not always applicable to a larger scale in the open, that is, it is not always *practicable;* but when it is, the practical man has in such a principle a safer guide than either tradition or his own experience can possibly be. In no enterprise can we ignore the *facts* of science; and if, as in this case, they have practical value no time should be lost by progressive winemakers in applying them to the operations in the cellar. The practical man must make the best of conditions as they are. He can not stop long to make experiments. He must get the best possible results in the least possible time. While trying to follow out the idea of improved quality he can not afford to make the variations in his experiments too radical or extreme for the sake of comparison, because he must at all times reckon on getting quality *with* quantity. And yet, even by way of changing only certain features of the operations at a

time, but leaving the ground work the same, comparisons between the results can be made that will furnish sufficiently reliable evidence of any errors made. There will also be sufficient indications, for practical purposes, of further changes necessary for better results. In such a manner the operations given were generally carried out, and while they may not be of much scientific interest they may perhaps give the practical and progressive winemaker some guidance in this new line of work.

What is contained in this small volume has been known and applied in European wine districts and is therefore not new, except in so far as its application to local conditions is concerned. A few have tried pure yeast, and others bisulfite of potassium, and again cool fermentations have been carried on successfully to some extent; but thinking that perhaps a short account of his own experience might be of benefit to the industry the author has written this manual with the hope that it may induce winemakers in general to work along the lines herein suggested. Nobody realizes more fully the difficulties of properly controlling the fermentations of dry wines than the writer, who is no novice or mere enthusiast in this vocation. With ten old style vintages and five vintages with improved methods as a record, he hopes to enjoy the confidence of the reader to some extent in what he maintains should be done toward the betterment of our wines. It is justly claimed that by such improved methods we are able to produce wines that are *better than those made in the old style;* and in the right locality we are even in a position to make *fine wines* in that manner with greater regularity and certainty.

The work from which these observations were taken was personally performed by the writer at Castle Rock Vineyard, near Napa, California, the property of Mr. Ernest L. Streich, a very experienced and competent winemaker. He was likewise im-

pressed with the necessity of improving the quality of wines in general and immediately took up the suggestions of Mr. Bioletti in the year 1906. The results have so far justified the application of the new methods, and we think that the wines so made are far superior to those made in the old way. Though working on rather a small scale—considering the usual estimate of a cellar by the mere amount of juice put through its vats—we employ steam power and give personal attention to details, the one insuring promptness and the other uniformity of the work.

In advocating these new methods it is much to be recommended to keep written records of the work performed, not only because these form a good training for exact observations but also because it is a good business principle to have them as a ready reference for the future. Practical experience is but a repeated mental record of similar results under similar conditions. Since, however, the human mind is not always capable of accurate memory there is likely to arise a confusion of facts and incorrect conclusions. Any judgment which is based on such experience is likely to be erroneous, especially if we consider the fact that vintages come but once a year. We are dealing with very complex conditions during winemaking and have to study the various causes and effects diligently if there is to be any real progress in our work, and if the experience gained is to be reliable. By reference to such written records we may be able to eliminate from our work such parts as do not seem to affect the results or affect them unfavorably. Without such mental direction we are apt to work needlessly hard with our hands. The combination of a ready hand and an active mind will in the end win better results than mere plodding and drudgery. Quite true that "blessed be the horny hands of toil", for these are behind every great achievement; and yet it

is also true that "to think is to act", because hard manual work without some leisure time for thought is apt to dull the mind and render us poor indeed.

The operations involved in these methods require an adjustment to the conditions not only of every vintage but also to every locality as well. It is not claimed that the demonstrations offered in these pages are at all times without fault in that respect, but they are at least meant to indicate that the work was done with such practical ideals in mind as would promote the quality of our wines. The reader should *not* expect an immediate solution of his difficulties in following exactly the same operations, but should draw his own conclusions from them and apply them to the fermentations in his own locality. It was, therefore, not deemed advisable to give the varieties of the grapes used in the fermentations shown in the various tables, but merely to present them as white or red grapes. The writer may be in error on this point, but he thinks it best to have the mind of the reader free from any prejudice and to confine himself strictly to the technical side of the fermentations. Such influence as the variety of a grape may have on the character of the fermentation involves also the conditions of soil and climate of that particular locality, and this ought to be a matter that each winemaker should find out at the cellar where he happens to be. In other words, the methods herein recommended can be of benefit only when intelligently adapted to the environments of a locality. Mere imitation or guesswork will never give any satisfactory results.

The object of this manual is, therefore, to show that by the reasonable use of sulfur for settling the white must and controlling its fermentation—with a similar use of bisulfite of potassium—by the heating of the red pomace and the application of

bisulfite, by the addition of pure yeast to all musts to start a prompt fermentation, as well as by the cooling of all fermenting musts, a product can be obtained that is superior to that made in the old "let alone" way. Pure yeast (*with cooling*) develops more alcohol than any "wild" yeast working under high temperatures, and cool fermentations seem to precipitate more tartaric acid and to check the formation of volatile acid, so that the wine tastes smoother and pleasanter. These advantages recommend an earlier harvest when the sugar is lower and the acid higher than the present custom allows. The result would be lighter and more drinkable wines—with 10½% to 12½% alcohol—which, however, require greater care in their making and handling.

The outcome of these methods herein set forth seems to be that greater *mildness* is developed in the wines so made, which is a characteristic often lacking in our native wines. Besides, they have the following general points in their favor: (1) early brightness, (2) a smooth and clean taste, (3) a well preserved aroma, (4) very good keeping qualities. And if with these methods we employ also (1) cleanliness, (2) promptness of manipulations, and (3) exactness of observation, the probability of unsound wines should be reduced to a minimum.

Various analyses were made by competent chemists of the wines so made, the alcohol being generally higher and the acids lower than expected from the composition of the grapes. It is well to know the proportion of alcohol, free acid and volatile acids, and the presence of a possible remnant of sugar, because these components give one a fair idea of the quality of the wine; but as "all science lacks a human side", so here too the final and most telling test rests with the senses of smell, sight and taste. This reveals the art of winemaking and is after all the

final and best judgment that can be rendered on the quality of a wine. If a wine is well balanced scientifically and leaves a pleasant memory on the tongue, and also does not have a deleterious effect on the human body, it comes very near being the ideal product of the grape.

Without the advice and assistance of others I would not now be able to present these observations to the public, and it is a pleasure to acknowledge my gratitude for such aid to Mr. Frederic T. Bioletti, who at all times was ready, by word or pen, to instruct and help me. For the opportunity given, as well as the encouragement and the confidence expressed, in the pursuit of this work I am under great obligations to Mr. Ernest L. Streich, at whose cellar and with whose practical and invaluable help these observations were made possible. For courtesies and favors shown and for the comparison of notes on the subject I am indebted to Mr. A. Repsold and to the manager of his cellar, Mr. J. Lechner. And lastly, I hold in greatful remembrance the late Professor George Husmann, my first teacher, to whose leadership this industry owes much of its progress.

RUDOLF JORDAN, JR.

2563 Washington St.,
San Francisco, California.
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QUALITY IN DRY WINES THROUGH ADEQUATE FERMENTATIONS

CHAPTER I.

THE USE OF PURE YEAST AND ITS ACTION.

A great advancement in winemaking was recorded when Pasteur and his contemporary scientists, toward the end of the last century, carried out a series of important investigations concerning the nature of fermentations. It is not the purpose of these pages to give an accurate account of the character of the germs or cells that have been found to be the cause of the process of alcoholic fermentations. Suffice it to say that there are various varieties of yeast germs whose capacity consists in converting sugar into alcohol and carbonic acid gas. Some of them are stronger than others in their activity, and it has been found that this difference in vigor is largely due to the conditions existing in the locality where they have their habitat and where they have been trained and cultivated to do their work. A notion to the effect that the quality of wines is inherent in the yeast itself has induced many winemakers to try such yeast on the musts of a different locality where by reason of different climatic conditions it failed to do its work properly, or at least far short of expectations.

Our California musts may be termed heavy or rich, being the product of a semi-tropical climate, and they have been found to require a vigorous yeast in order to convert promptly *all* the

sugar of the must into alcohol. Our University has wisely recommended the use of socalled "Champagne yeast", this having originally come from the regions of middle and southern France. German yeast from the Rhine and Moselle region has been tried by the writer, but was found to be inadequate for the task with our musts here. This will be further explained in the records of some of such fermentations. And again, when the cooling of the fermenting must is applied there is required a certain resistance to the effect of a lower temperature, which is a notable trait of the Champagne yeast. Even with this particular variety of yeast there seems to be a slightly variable effectiveness with the different kinds of grapes, so that its action was at times more prompt in some musts than in others. Pure yeast, for that matter, may degenerate into "sports" or become contaminated with other ferments when not kept away from the main location of the fermentations. It is, therefore, not only the acquisition but also the preservation of the yeast that we have to keep in mind. Cultivated or developed yeast resembles much a cultivated plant and will like it lose its vigor by unfavorable surroundings. To insure its prompt effect it is necessary to use a fresh supply of yeast for every vintage, even though it may possibly, by continued use, become attached to the place and develop there by itself just like the "wild" forms of yeast. Besides, the use of pure yeast means also the exclusion of many undesirable fungi or moulds that often do harm to the wine. The object of pure yeast cultures is to let them do the work alone so that the resulting wine may be as pure as it is possible to make it; that is, all other ferments that are likely to be deleterious in their effect on the wine should be kept out from the very start. If, therefore, the yeast can be introduced into the must in an uncontaminated condition there is likely to be

less danger from any socalled secondary fermentation later on, which is but the action of destructive bacteria that entered the wine before or during fermentation. Or, again, such secondary action may not show itself in a noticeable fermentation but in a gradual breakdown of the wine.

It stands to reason that if the pure yeast is well developed, that is, if it contains large and strong individual cells in sufficient numbers, when it is introduced into the wine, it will remove or eliminate the sugar more thoroughly, besides assimilating other nutriment from the must for its life and growth or such as would otherwise serve the bacteria or harmful germs with nourishment. Roughly stated, remnants of sugar and unconsumed or unprecipitated albumen are supposed to form the best food for such bacteria, and on that account it becomes necessary to have as vigorous a yeast as it is possible to procure. The fermentation of the must is not as simple a process as it may appear, and if we come to realize the action of all these good and bad germs and their effect on the taste and smell of the wine, we can readily see that it is of paramount importance to exclude as much as possible all germs and moulds and bring the fresh must in contact only with the uncontaminated cells of the pure yeast.

This brings me to the actual manipulation of the yeast in sufficiently large quantities for daily use during the vintage. It has been suggested that all we need the original pure yeast for was to start the first fermentation, after which it would only be necessary to transfer the active must from tank to tank. This would be much easier, but here again we fail to understand the meaning of "pure" yeast, because such yeast can stay tolerably pure only when kept by itself and continually nourished with fresh and defecated must. Any transfer of must

started in a tank with pure yeast is exposed to the very contamination that should at all hazards be avoided; for, the very supremacy of that yeast in a fermentation depends on its purity and on the absence of all other ferments that may cause trouble in the wine. Even when keeping a fresh supply of pure yeast continually on hand during the entire vintage we are taking chances on its remaining pure, but with reasonable care and cleanliness there is less likelihood of contamination than there would be in successive transfers from tank to tank of the must originally started with yeast. The extra work for the preservation of the purity of the yeast can not well be avoided.

The yeast from the University at Berkeley is sent out in glass bottles stopped with a cotton plug and set upright in a basket. They contain a small amount of a brownish liquid in which are seen dark colored lumps. The latter are the yeast germs and will keep for some time, although the sooner they are set to work the better for the vigor of the yeast.

As far back as August, 1906, Mr. Frederic T. Bioletti published a circular No. 23 which gave explicit directions concerning the preparation of the yeast so sent for a larger supply. With some slight changes the directions are again given to make the reader familiar with the process. It is best to keep such supply in a separate chamber if possible to guard against the usual contaminating influences existing in the cellar proper. For all the operations herein given the yeast was therefore kept in a little room near the main cellar and one that could be made airtight and could be heated if necessary by steam.

Having received the small quantity of pure yeast as above mentioned, we proceed as follows:

(1) Take a 1 gallon demijohn—preferably without any wickerwork—and sterilize it by filling it nearly full of water

and putting it in a large kettle or pot of water and let the latter boil for some time, say 20 or 30 minutes. Plug up the demijohn with clean absorbent cotton and let it cool a while. Then pour out the water and plug it up with cotton again.

(2) Take a quart or more of fresh grape juice at about 20° sugar and mix same with an equal amount of water that was previously sterilized and cooled, such as was contained in the above demijohn.

(3) Take this last mixture and pour it into the demijohn and close it with a cotton plug and set it in a vessel of water and let the contents come to a boiling point or nearly so, and keep it there for an hour. Then cool the demijohn gradually down to 65°.

(4) Now pour a little alcohol on the plug and set fire to it so as to destroy all possible germs that may have gathered on it. Treat the plug of the bottle containing the pure yeast in the same manner. Pull out both plugs and pour the yeast into the demijohn and plug up the latter again with fresh cotton. Now place the demijohn in a warm kitchen and shake it up three or more times a day. In a day or two the must will be in full fermentation.

(5) Meanwhile crush enough grapes to fill a five or ten gallon keg that has been thoroughly cleaned with hot water after treating it with *cold* water to which a little surfuric acid was added. It is perhaps needless to warn the reader against using hot water in connection with the acid because of its danger in spurting up and injuring one's eyes. When drained and dry burn a goodsized but thin coated sulfur match in the keg. Take the must and pour it into the keg in three lots, shaking or rolling it between times so as to cause some of the surfur to

be absorbed by the must. When full let it settle for 24 hours at least.

(6) Take a new half inch rubber hose, clean it well with hot water and draw off the must from the keg free from the sediment at the bottom into a wide tub made either of oak or preferably of glazed fiber, this also having been scalded with hot water. Then take a new and clean enameled dipper or small saucepan and *aerate* the must by lifting it a few feet above the tub and letting it fall back on to itself. Keep this up for at least five minutes.

(7) Now take the demijohn containing the fermenting pure yeast and pour it into the tub. Then aerate again thoroughly the whole mass. After that put a couple of clean sticks across the tub and cover same with a clean cloth. Repeat the aeration three times a day so as to supply the yeast cells with oxygen which they need for their growth and development.

This tub will hold about 25 gallons after it has been gradually filled up in a day or two with more must settled in the same manner as above described. From time to time the rim of the tub should be washed out with a sponge scalded in hot water in order to remove any scum that may form a breeding ground for acetic or other bacteria. If a second tub can be placed alongside, a complete transfer can be made at times, thus enabling us to clean the first one. In order to maintain the yeast supply at as even a vigor as possible regular daily additions of defecated or settled must should be made. If the supply exceeds the demand it is better to discard some of it into a fermenting tank; for, it is quite important that the starter in a tank should be active and show about 10° of sugar on the average. This is the one great difficulty in the application of pure yeast, and any negligence in keeping it at an even strength

will be noticed in the fermentations, or rather in the comparative promptness with which they commence.

Everything in connection with the manipulation of the yeast should be scrupulously clean, and the reader is supposed to be familiar with the meaning of sterilization. Water at a boiling point of 212° or even at 170° F. is the usual agent to render harmless or kill any obnoxious germs attached to anything we use, and an immersion into such water for a reasonably long period of time will suffice to sterilize all tools or vessels used. The French scientist Pasteur proved that such exposure to heat destroyed any undesirable bacteria or germs that may have entered the wine at one time or another.

With great exterior cleanliness in the cellar it still happens that such destructive germs appear in the wine, and the supposition is that they enter it at the start, that is, they are contained in the must, being brought in from the vineyard by the grapes themselves. The very purpose of these careful methods is to remove the impurities from the must by settling it, thus eliminating a large portion of those harmful germs from the start. Pure yeast should, therefore, have a clear field to work in, even though it does by its superior aggressiveness keep an upper hand in the fermentation itself. Sulfuring the must should therefore be accepted as a legitimate means to benumb the objectionable spores in the must which are drawn down by the solid particles in it, and most of them are no doubt destroyed by the fumes of sulfur or by the action of the sulfurous acid contained, for instance, in bisulfite of potassium. Of this I shall have occasion to speak later on.

Such a process will give us relatively pure fermentations, and in practice the better keeping qualities of the wines so made

warrant all the extra labor and care that such methods impose upon the winemaker.

After the addition of the pure yeast to the tub of defecated must there may be some delay before the fermentation sets in. This is due to the stunning effect of the sulfurous acid in the must. By repeated aeration this retarding action of the sulfur is removed and the yeast, becoming accustomed to the sulfur, will soon be in action in spite of it. To avoid such an annoying delay it is perhaps better to take a demijohn, sterilized as before, and burn a little sulfur in it. Fill this half full with fresh must and shake it well. Let it settle well and pour or syphon a quart of it into the demijohn containing the pure yeast which is in full fermentation. When the fermentation is not affected or is again in action it is quite safe to add the yeast to the tub of must. Once used to the sulfur the yeast will show as vigorous an action as is desired. The point to be remembered in all of these operations is that the yeast should take a hold of the must, in the tub as well as in the tanks afterwards, without much delay. No other germs should have a chance to get ahead of it.

In order to have an ample supply in a small cellar for the needs of the fermentations we should take a few 25-gallon barrels and put them on a skid near the press. On the basis of a 1% addition of yeast we need about 25 gallons daily of fresh must that has been defecated for 24 hours. This will supply 2500 gallons of must to be fermented. At times a larger addition of yeast becomes desirable and it is always better to have too much than too little of the yeast on hand. To facilitate the defecation of the must for the operator the use of bisulfite of potassium is to be recommended. This can now be readily procured in the market and its use has been advocated by Mr. Bioletti of the University at Berkeley. My own experience with

it has been very satisfactory and it must be admitted that it is a great factor and aid in the new methods herein discussed. Used at the rate of 1 ounce to 25 gallons in the defecation of the must for the yeast it suspends any spontaneous action in the must for 48 hours. It can be dissolved in a little hot or rather warm water and then added more easily and equally to any must or pomace to be held in check; besides, one is sure of the quantity added taking effect, which is less certain with the sulfur fumes.

Keeping on a rack near the press a few 25-gallon barrels, thoroughly sterilized of course as above advised, the must for the yeast can be kept in rotation from day to day without intermission; and this continuous supply will insure the vigor of the pure yeast.

The addition of 1% of the volume of the must to be fermented forms as a rule a sufficient starter. My experience leads me to think that more rather than less should be used. Much depends on the condition of the yeast. It is hard to systematize one's work so that a fresh supply of must is added to the yeast at the same hour every day, and it should be practically in the same condition six hours later when taken for a starter. As we do not always draw from it at regular intervals the yeast may not always show the same degree of development or vigor. One is apt to believe that if the yeast lacks vigor or development a larger quantity used as a starter would have the same effect on the fermentation, but if we consider the life and characteristics of a yeast cell it will give us a better idea of the functions and the work of the yeast.

An attempt on my part to properly explain the nature of a yeast cell would perhaps not be quite scientifically correct and the reader is advised to pursue the matter for himself; but suffice

it to state that it is an organism of very small proportions, of an oval or round shape and covered with a skin or membrane through which it absorbs its nourishment. It multiplies by what is called "budding", and during its life has the two functions of propagation and of converting the sugar of the must into alcohol and carbonic acid gas. For its life and development it also needs certain albuminoids for the nitrogen contained in them, as well as some mineral salts of iron, lime, potassium and magnesium, such as potassium phosphate and magnesium or calcium sulphate, which are more or less contained in the must. The absence or presence of these nutrients determine the action of the yeast cells, and the difference in the composition of various musts is likely to produce a noticeable variation in their fermentations. Above all the yeast needs the oxygen contained in the air and a certain amount of aeration is absolutely necessary for its full activity. As stated above, the yeast cell has two functions that make up its existence, namely, (1) its growth, development and propagation, and (2) its fermentative activity, a form of work somewhat comparable to the making of honey by the bee. It is strange too that the yeast cell produces its own poison or toxin, for, the products it excretes, so to speak, will in the end stop its activity. Like every other organism the development of its vital functions is essential for its proper activity. Young cells just separated from the parent cell are not as fit to perform the work as older ones are. They especially need air or oxygen for their growth, and in the presence of a large supply of air I have found that the fermentation is apt to be very sluggish in the beginning, which observation seems to agree with the statement that under such conditions the vital function of the yeast is developed at the expense of its fermentative activity. As we shall see in other chapters the restraint put upon the

yeast by sulfurous acid is more in the nature of preventing propagation and of confining it more to its fermentative action.

What we need, then, in a yeast that is to take immediate hold of the fermentation, is an abundance of cells in the prime of life, and these we may expect to find in yeast that has somewhat subsided from a violent fermentation and shows about 10° of sugar according to Balling's saccharometer, and has a temperature of about 75° to 80° F. At such a stage it is likely to contain the largest number of well developed cells and these are indispensable in a starter for the tanks about to be fermented.

A process like alcoholic fermentation should be uniform throughout, that is to say, there should be a gradual decrease of the sugar in the must and a steady increase of the temperature. A slow start as well as a long drawn out finish must always be considered as grievous faults in any fermentation. Again, a drop in the temperature at the end undoubtedly indicates a sluggish activity of the yeast. This has occurred in vigorously aerated musts without the use of sulfur being employed, the precipitation of solids being attempted by letting the must fall in a spray back on to itself. Here it was found that the fermentation started very slowly and then suddenly became very violent, finally winding up again very slowly. In other words, the fermentation lacked an even progress, which latter condition is a reasonable requirement for the economy of labor and the better results in the wine.

Hence it becomes imperative for a uniform fermentation to have the yeast in a well developed condition when it is added, and if possible by some means, as the use of sulfurous acid, to confine its activity strictly to its supposed work. When that is well done to the very end, there is little likelihood for other bacteria that get into the must to feed and develop on the remnant

of sugar still unconsumed or sluggishly converted by the yeast due to its impaired vigor or strength. In such instances an explanation may be offered to the effect that either the yeast cells lack oxygen or the proper nourishment. This would indicate that there may be such a thing as congeniality between the yeast used and the variety of must, just as there exists a similar harmony between the resistant vine and the variety of the scion grafted on it. While, therefore, the Burgundy or Champagne yeast may be in general well adapted to our conditions in this state, where heavy musts prevail, there may be a possibility of other kinds of yeasts, when properly acclimatized, becoming fitter agents for the fermentation of certain varieties of grapes or their musts. These finer points in the work of winemaking with a view to quality may still be established by men of science, and would no doubt result in bringing out characteristic aromas or bouquets in the wines so made. In my own experience there have been cases of fermentations whose peculiarities are evidently due to the composition of the must rather than to the condition of the yeast, although it must be admitted that it is a very difficult matter to always have the yeast in prime condition.

The quantity of 1% of the volume of must to be fermented was given as requisite for a good starter. If too little is added a sudden increase of cells is apt to take place, and the young cells so formed are not likely to perform their fermentative functions as well as older or mature ones. If too much is added there is less probability of propagation, but also a possibility of an initial violent fermentation and a longer duration. Again, if additions are made subsequent to the 1% as a starter there may arise certain by-products, such as glycerine, sometimes desirable and sometimes not.

One point in favor of the Burgundy yeast is its quick recov-

ery from the effects of cooling, which aid to better quality in dry wines has not been fully appreciated in this state. While dependent on an inexhaustible supply of cold water it is worth while to consider its effects and a later chapter will therefore treat of the benefits of cooling.

Furthermore, this yeast, as well as perhaps other cultivated yeasts, has the laudable peculiarity of doing more thorough work, and of producing apparently more alcohol when the temperature of the must is low, than under the old method of leaving the fermentation to its fate with "wild" yeasts and higher temperatures. It may be objected to on the ground that our California wines show as a rule more alcohol than they should to make them a pleasant beverage, but in conjunction with cooling during fermentation, which has proved to eliminate much more tartaric acid, it enables us to harvest the crop a little earlier when the sugar is not so high in degree. Of course, grapes should be ripe to make good wine, but in this climate there is always a danger in obtaining too much body or extract matter when the grapes hang beyond real maturity. This is notably the case with some white wines which through late harvesting are apt to acquire a Sherry flavor and taste.

The use of pure yeast has, therefore, much more in its favor when employed in conjunction with a prompt harvesting and the cooling of the must as auxiliaries to better quality in wines.

The difficulty of keeping the pure yeast supply in a constantly vigorous condition has evidently induced some Frenchmen to overcome the trouble by an invention that may prove of assistance in that respect. The idea briefly stated consists in preserving and enclosing the yeast germs in a dry or dried gelatine preparation made up in plates or tablets of about 4×4 inches and ⅛ inch thick, several of them being braced horizon-

tally in a small metal frame, this again being encased in a metal box with a small air hole plugged with cotton. The settled must is to be poured into this box and when fermentation begins therein after the gelatine is dissolved, the contents of the box are poured into the tank about to be started. This would really constitute an ideal way of starting a fermentation with pure yeast, as the latter is not exposed to any contamination by the moulds and fungi in the air. It seems to be similar in plan as the use of compressed yeast which is a familiar agent in the household where bread is made; and the simplicity will appeal to any winemaker who has ever taken care of yeast. This innovation is certainly worthy of a trial, but should in reality first have the sanction of the trained men at our State University, whose investigations, after all, must remain the basis upon which all practical operations are conducted.

Various observations with regard to the action of pure yeast will be offered in a later chapter where the actual course of fermentations appears as illustrative of the work pursued.

CHAPTER II.

SETTLING OR DEFECATION OF WHITE MUSTS AS A BASIS OF QUALITY.

Much of the troublesome turbidness of white wines, as well as their surplus of extract matter and their yellow color, can be avoided by removing at the very start the greater part of the solid matter contained in the must by allowing it to settle for 24 or 36 hours before fermentation starts in. The must thereby becomes fairly clear and the effect of such defecation proves that must so treated will produce a wine free from the faults above mentioned. In order to accomplish this it is necessary to be able to suspend the action of any ferments for that period of time, and the readiest agent for that purpose is sulfur or rather sulfurous acid either in the form of sulfur fumes or in the salt known as bisulfite of potassium.

This previous precipitation of the solids in the must is all the more to be recommended for white wines, because, unlike red wines, the tannin in the wine is insufficient to eliminate the albuminous matter, which is one of the main causes of turbidness. Sulfur so used acts as a germicide or at least renders the various germs and moulds inactive, and the solids carry these down with them and thus the must is made comparatively free from obnoxious bacteria. Care and skill is required in this operation, for it is not the intention to use sulfurous acid as a preservative as in the socalled and wouldbe Sauterne types of this state. With a reasonable amount used it happens very rarely that the wine has any of that unpleasant dryness which

is so characteristic an effect of sulfur. In the segregation of the dirt or sediment from the must it has been found that the wine made therefrom contains quite an amount of the sulfurous acid, which proves that most all of it is eliminated from the must by settling and the balance during the fermentation. The finished wines made by this process have never revealed the presence of any excess, in fact, they were singularly free from its effects; so that the conviction of its harmlessness in the must can be safely asserted. All that is required is the temporary suspension of germ activity during which the must has time to settle and become clear; and also to render the field open for the unobstructed progress of the fermentation by the pure yeast accustomed to sulfur.

The combined use of sulfur fumes and of bisulfite of potassium dissolved in a little warm water has been found most practical with us. If the must from the press empties into an underground but open cement sump it may be covered with canvas so as to confine the sulfur fumes. A piece of board suspended under the pipe which delivers the must from the press will sufficiently scatter the liquid so as to absorb some of the sulfurous acid. Hardly enough absorption, however, takes place to be able to rely on a safe suspension of fermentative or bacterial activity, so that the additional use of bisulfite will become necessary. This may be added to the pomace or freshly crushed grapes or to the juice in the sump as occasion may demand. A low 1200 to 1500 gallon tank by the press, into which the grapes are run from the crusher, adds to the facility in handling white grapes for defecating the must. In the beginning of the vintage the air is not yet filled with wild yeast and other germs, so that less sulfur will do the work quite as well; but later on the control of the must needs more care and a prompter

use of sulfur to prevent fermentation before the juice is properly cleared.

The amount of bisulfite to be used varies, of course, with the weather conditions prevailing at the time. Considering that there is some absorption of the fumes, the quantity of bisulfite used in addition should be about from 2 to 4 ounces per 100 gallons or from 4 to 8 ounces per ton of pomace in the press or in the tank mentioned. If, however, it is preferred to pump the must into a sulfured and closed tank for defecation and a spray is used for that purpose, the absorption of sulfurous acid will be greater and it will take less, if any, bisulfite as an auxiliary to keep the must inactive for 24 or 36 hours. As to the quantity of sulfur to be used when burning the ordinary strips in the tanks to be sulfured, it has been estimated that about 10 ounces suffice for a volume of 1000 gallons. The ordinary strips, when not heavily coated with sulfur, weigh about .075 oz. to the inch. This calculation is, of course, subject to the habit of making the strips, and it would conform to the exact methods herein upheld to settle the all too prevalent guessing in such work by the decision of a small scale that will accurately indicate ounces and fractions thereof. The above figure of 10 oz. for a thousand gallons volume seems rather high, especially if a spray is used that will squirt the juice in all directions in the tank. We have found that strips of 15 to 18 inches, or about 1¼ oz., will enable us to keep from 800 to 1000 gallons inactive during a defecation of 24 hours. Hot weather and consequent warm must will require more sulfurous acid in one or both forms, and this manipulation must be left to the good judgment of the intelligent winemaker Homemade strips not too heavily coated will run about 15 inches to the ounce of sulfur.

In burning sulfur we may as well heed the advice often given that it should not be allowed to drip to the bottom of the tank or other container, because it is thought that the sulfur may impart a disagreeable odor to the wine. This is especially the case when there is still some water in the tank which may cause the sulfuretted hydrogen smell sometimes noticed in newly made wines. This may also be caused by the action of the yeast on the free sulfur on the grapes or in the must and any precaution that will prevent such an occurrence should be employed by all means. Fig. 1 will illustrate the point in question. For the open sump a piece of a board hung by a wire through the middle forms a safe appliance to prevent dripping. For the closed tank a sulfur cup or tube made of porcelain or copper is an old invention that performs its duty well. Air holes or slots on the sides will make the sulfur burn quite well. There is a prejudice against the use of such a device because it requires a little more care, but there is nothing in the charge that the sulfur does not burn as well or as effectively. It may burn a little more slowly but the air is as readily expelled as with the strip burnt without restraint. The main point or purpose of sulfuring is to drive out the air and replace it with the gas formed by the burning sulfur. Neither the melted sulfur nor the carbon of the burnt cloth or paper are desirable additions to the tank into which

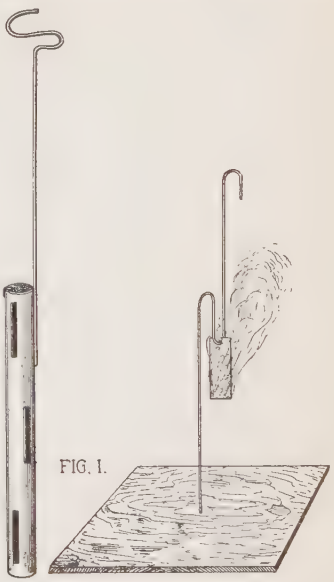


FIG. 1.

wine or must is put, and these little precautions form part of the network of these improved methods whose total intent is directed toward the improving of the quality of the wines. Carelessness and negligence are the worst of obnoxious bacteria during vintage time and spoil much wine.

The spray used for sulfuring the must is illustrated in Fig. 2 and represents a tinned copper tube bent at right angles, attachable to the hose by means of a 1¼ inch coupling, the tube itself being 1 inch in diameter and punctured in its upper part of the portion that enters the tank, and has a detachable end piece against which the must is forced and then deflected into the openings on its sides, thus causing a stream as seen in the illustration. This is especially effective when the tank has a hole in the middle of its head, thus insuring an even spread of the must all around.

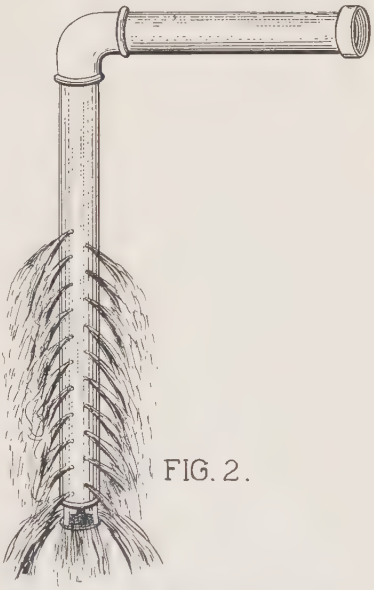


FIG. 2.

When sulfuring the sump which receives directly the must from the press this same or a similar spreading effect can be obtained by suspending a piece of a board under the pipe delivering the must, which scatters it sufficiently for the absorption of the sulfur fumes. These cement sumps, when once well seasoned, are a great help in the rush of winemaking, because in these operations they dispense with the pumping of the must for

defecation by acting as receptacles for that purpose whenever convenience requires it. In that case experience will teach how much bisulfite should be added to make sure of the must remaining quiet for at least 18 if not 24 hours. During the stress of the work we may not always be able to defecate the must the full time that it should have, but even 18 hours will suffice and such a settling is better than none at all. It is very hard to conform to the rules that make for a superior article, but we should at least try to work as close to the plans of such a system as is possible under the circumstances.

While we have worked with one press only, it is more advisable to have two where time is to be saved and labor made more easy. All such considerations do not really belong to the pages of this book except in so far as the necessity of readier and quicker facilities form an important part of the operations recommended as the new methods. Crushing, defecating, pumping, and cooling have to be done sometimes within a few hours, not to speak of the special care that the yeast supply demands at all times. So it may happen that we use what might be termed an overdose of bisulfite, but during the rush it may be advisable to slightly increase the quantity used. This does not mean that *any* quantity is recommended so long as the must is kept inactive, because that would lead to the sulfur taste in the wine, a most objectionable fault; but rather that the effect of the sulfurous acid, thus introduced into the must even in larger quantities than above given, will be largely nullified in the subsequent fermentation. We may err in these practical applications of sulfur to the must, and the sum total of individual experience will finally ren-

der a proper verdict in the matter, provided that we are able to learn from such mistakes by a careful record of such operations during the vintage. Otherwise it will all amount to a haphazard guess, and that is never a safe guide for the progress of the work.

What sulfurous acid is present in the must when the yeast is added seems to have a steadying effect on the fermentation which thereby proceeds with greater regularity and promptness. As has already been remarked, yeast that is trained to the presence of sulfur is somewhat protected against the invasion of moulds or fungi, and when the must has likewise been subjected to sulfurous acid there seems to be all the more reason for the relative purity of the resulting fermentation. As an auxiliary sulfur, therefore, becomes an important factor in a thorough fermentation. In a later chapter on fermentations we shall have occasion to observe this more particularly. A most notable instance of the influence of sulfur on the fermentation will be seen in that of the sediments from the defecations of the musts. In the wine made from these there remains rather more sulfur than is desirable, and the color of it is much darker. It also has too much extract matter, giving it too much flavor or rankness. These sediments were usually thrown into a large sump, sometimes started with yeast and sometimes not, and left entirely alone. The temperature of these fermentations showed a maximum of about 73° F. which in part was caused by the sulfur in allowing the yeast to work but very slowly, so that the generation of heat almost equalled the radiation of it in the sump. And yet, the duration was not as long as one would presume under such conditions.

In order to avoid as much color as possible in white wines such defecations are highly to be recommended, eliminating as they

do much of the solid matter that is likely to develop color and extract or flavor. The use of sulfur seems to prevent also the oxidation of the must, which in itself is one of the causes of color. If, however, we wish to still further prevent any color to develop in the white wines the last pressings of the pomace should also be kept out. These were invariably added to the sediment must fermenting in the sump, so that the resulting wine contained about all what was considered objectionable in good white wines. The loss from both these segregations amounts to from 5% to 7% of the must made up, one half of this being chargeable to each operation. In view of the improved quality of the wines so made, this seems to be a negligible loss. There is always bound to be a small amount of inferior wine at every vintage as ordinarily conducted. With this method of clearing the must before fermentation we collect what is the cause of much disease in wines and ferment this by itself, thus leaving the bulk of the wine in a sound condition from the start.

The argument that the last pressings of white wines are necessary because of the tannin contained therein may have some weight, but between the two evils of lack of tannin and too much color the first seems to be the more preferable one, for subsequent operations, such as fining, will give an opportunity of adding the usual amount of tanning for clarification, which amount is generally in excess of what I consider good for the pleasant taste of the wine. To make the white wines colorless in the beginning lays the foundation for that beautiful greenish golden color later. Of course, the wines so made are not proof against the subsequent influences at work to make it darker, but we have at least deprived the wine of the substances that bring about the objec-

tionable brownish golden color which spoils the looks of any white wine.

What should be borne in mind at all times, however, even when there is lack of room and of time, is that the purpose of this work is to render the must as clear as possible and at the same time to keep it inactive or free from any ferments; so that the pure yeast may have an unobstructed right of way and clear field of action.

CHAPTER III.

AERATION OF THE MUST, BEFORE AND DURING FERMENTATION.

Scientific investigations have shown that the yeast needs air for its life and growth, and therefore also for its function as a fermenting agent. For white wines the defecation of the must is deemed advisable because a clear juice is not only a cleaner but also a surer field for the yeast to work in. The must so treated is deprived of its particles of air that cling to the solid matter which is precipitated in the process. Furthermore, a certain amount of the sulfurous acid taken up by the must should also be removed by exposing the must to the action of the air. A part of the acid will nevertheless remain in the must and this has been found to play an important role in the control of the fermentation. When the must is to be pumped into a closed tank care should be taken that such a tank is free from any sulfur gas and that it is fresh and clean, which may best be accomplished by washing it out with fresh water first. In order to give the must the desired aeration the use of a spray as given in the previous chapter is much to be recommended because it breaks up the liquid and gives it a more complete exposure to the air. To do this still more effectively there should be a hole in the middle of the tank. If it is thought advisable to retain more of the sulfurous acid in the must a simple end bib may be used instead. At any rate, some aeration should be employed if the fermentation is to be satisfactory throughout.

Some experiments with extra aeration, such as is afforded by pumping the must over in itself from the bottom of the sump, for instance, and back again through a rose spray, dropping it several feet to its surface, were tried to note the effect. If this operation be continued for some length of time it answers the double purpose of aeration and of the precipitation of the solid matter, so that defecation by means of sulfurous acid could be avoided altogether. This oxidation, or action of the air, tends to render some albuminous matter insoluble, causing it to be precipitated also either naturally in time or by fining later on. In white musts made from red grapes the pink coloring matter is also rendered insoluble and flaky by more or less aeration of the must and is thus eliminated to a large extent; but any *excessive aeration* is apt to bring about a brownish tinge in the wine, as can be readily seen in the appearance of a dark brown scum during such aeration. Again, the use of much sulfurous acid, in the form of fumes or bisulfite, will at first remove the color, but this is likely to return during the aeration after defecation or any subsequent exposure of the wine to the air. In the treatment of such musts, therefore, it is advisable to use sulfur sparingly or effect the defecation entirely by a somewhat prolonged aeration, even at the risk of having a rather irregular and violent fermentation, as we shall see in subsequent examples.

In all such free aerations there is always danger that the moulds or fungi floating in the air may enter the must and cause trouble later on, especially if in this operation no sulfur is used at all. Much depends, of course, on the prevailing temperature of the weather and on the general cleanliness that is observed in the cellar during winemaking.

Except as was noted above, no distinct benefit was attained by long aerations, and we found that a disturbing irregularity resulted in the nature of the fermentations. They were slow to start, then became very violent and finally wound up in a drawn out finish. In other words, they are not as steady or as intense in character as are the musts that were defecated and received only the ordinary aeration that takes place in the fermenting tank as above mentioned. There seems to be an absence of "emotion" in the latter and they "go the even tenor of their way". A plausible explanation of this sudden upheaval of the fermentation in the much aerated musts lies in the assertion that the yeast cells under a large supply of air are inclined to develop their vital functions in preference to their fermentative functions, that is to say, they will multiply in numbers before they will turn to their work of fermentation. This view agrees with the observation made that there is a lull at the beginning, during which the yeast cells develop in number, followed by a sudden fermentative activity of unusual violence during which the yeast seems to spend its whole strength, because at the end there appears to be a long struggle to eliminate the last remnant of sugar; in other words, the period from the time when the saccharometer shows +0 to the time that it indicates —0 and the wine is dry to the taste is excessively long and open to the various deleterious influences which menace the wine at all sluggish stages of the fermentation. To illustrate the point in question let us take the cases of two white wines, the tables of whose fermentations are given herewith.

Before considering these tables it may be well to state that a fermentation is taken to begin when the yeast is added, but in practice it is best to assume that the start is made when bubbles

of gas appear on the surface; and that it ends when the saccharometer indicates —0° and the wine is "dry" to the taste, and all action has subsided. Most fermentations have a windup or finish after the must is "dry", and the shorter this period is the better the indication that the yeast had vigor. In the table below this part of the duration is not distinctly enough shown.

TABLE 1.

900 gallons White Must from Red Grapes. Sugar, 21.5°; temperature, 61° F.

No sulfur and no defecation; settled in sump for 24 hours. After the 9th hour **aerated for 1½ hours** with rose nozzle over sump; left over night for 15 hours to settle, then pumped into a 1000 oval and added 10 gallons pure yeast.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
18	20	62	1.5	
24	18.5	65	1.5	
24	16	72	2.5	
24	14	80	2.	
7	12	84	2.	Cooled 2½ hrs. to 76°.
17	4	80	8.	
24	+0	83	4.	
138 hrs. or 5 d. 18 hrs. 6 d. finish to	—0			Average loss of sugar per 24 hrs., 3.91°.
11 d. 18 hrs.	max. temp. 84°		21.5°	

The heat developed in all alcoholic fermentations is due mostly to the chemical process of the breaking up of the sugar into alcohol and carbon dioxide, but it has been stated that no

doubt the individual cell of the yeast has a temperature of its own and that a large accumulation of them would therefore increase or add materially to the heat generated by the chemical action mentioned. Higher temperatures are considered more favorable to the formation of young cells than temperatures under 80° F., and hence the rapidity of the fermentation at the maximum temperature. The table shows a drop of 8° sugar in 17 hours just after the maximum temperature was reached. One would expect a better finish even with the check of the cooling, but in the next 24 hours it still drops 4° down to +0°; and the record states that for 6 days the surface showed marked activity of the yeast and that only at the end of that time was the wine really dry. Comparing such a fermentation to others where sulfurous acid had been present I am inclined to the belief that aeration and the absence of sulfur are the causes of the peculiarities of this fermentation, both of these conditions favoring a large increase of the number of cells originally introduced into the must. The long finish can only be explained by assuming that after the young yeast cells had thus tardily developed and consumed 12° sugar in two days their vitality outlasted their usefulness, and their activity seems then to have been spent in assimilating whatever further nutriment there was in that apparently rich must. The resulting wine was of good quality and kept very well.

In Table 2 we have a slower start (39 hours) than in Table 1 (18 hours), and my notes declare this to have been a very gentle or weak fermentation, which fact may also be gathered from the course of the temperatures of the successive days. There was less aeration by ½ hour and the starter also was a similar quantity of yeast, being the supposed requisite of 1%.

With a much smaller quantity of yeast one might have expected such a slow beginning of the fermentation, because in that case the tendency of the yeast cells is supposed to be to develop in numbers before acting as fermentative agents. This, therefore,

TABLE 2.

700 gallons White Must from Red Grapes. Sugar, 21.5°; temperature, 60° F.

No sulfur; no defecation; settled in open tank for 26 hours; after the 20th hour **aerated for 1 hour** with rose nozzle over tank, 3 hours thereafter pumped it into 750 oval and added 7 gallons yeast.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
39	19.5	66	2	
24	16.5	74	3	
24	13.	76	3.5	No cooling.
24	8.5	79	4.5	
24	5.5	81	3	
24	3.	78	2.5	
24	1.	76	2	
24	+0	76	1	
207 hrs. or 8 d. 15 hrs. 2 d. 9 hrs.	finish to —0			Average loss of sugar per 24 hrs., 2.49°.
11 d.	max. temp. 81°		21.5°	

seems to be a case where they lacked proper vigor, which was pointed out as one of the difficulties in handling pure yeast. No cooling was employed because there was no excessive development of temperature. A further aeration toward the end of the process might have given the yeast new life. The varieties of grapes

were very similar in character and the fermentations were concurrent and in the same location; so that the fault seems to have lain with the yeast. Since the average loss of sugar in 24 hours is a proper indication of fermentative activity, a comparison of the two averages (3.91°—2.49°) shows more clearly the sluggishness of the latter. We may therefore conclude that the initial aeration did not invigorate the weak yeast. The resulting wine remained sound and bright afterwards, and the suspicion had at the time that other germs or bacteria got into the must and weakened the yeast action can not be sustained. For the credit of the pure yeast it must therefore be said that it did its work nevertheless even if in slower time.

Again, in Table 3 let us consider a much heavier white must fermented a week later and observe its conduct under a very similar treatment. In these cases the aeration took place after the sump had been filled so that the must did not have the proper protection against outside influences or the inroads of floating ferments, such as the use of sulfur affords. Nevertheless by covering up the sump and observing great care and cleaniness no visible action was noticed in the must. In hot weather and in the midst of the vintage it is always risky to delay the addition of pure yeast because our very purpose is to put it to work as soon as possible in order to forestall the action of wild yeast germs. As before mentioned aeration here had the double effect of supplying oxygen and of precipitating the solid matter and impurities of the must. The table on the next page will illustrate the character of the fermentation.

The sugar and the initial temperature of the three cases under discussion being the same as well as the operations performed, the difference in the character of the fermentations may therefore

be assigned principally to two causes—it being also admitted that the weather conditions were very similar,—namely: (1) the composition of the must, and (2) the vigor of the yeast. In all three, however, there was rather a long drawn out finish, that is, the formation of gas did not cease with the disappearance of the

TABLE 3.

800 gallons White Must. Sugar, 21.5°; temperature, 60° F.

No sulfur; no defecation; settled in sump for 22 hours; after 19th hour **aerated for 1½ hour** with rose nozzle over sump; pumped into 900 tank and added 10 gallons pure yeast.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
8	20	64	1.5	
12	18	68	2	No cooling.
24	9	83	9	
24	3	91	6	
24	+0	91	3	
24	—0	89	0	
116 hrs. or 4 d. 20 hrs. 5 d.	finish till quiet.			Average loss of sugar per 24 hrs., 4.45°.
9 d. 20 hrs.	max. temp. 91°		21.5°	

sugar; for, we can not consider a wine to be *through until it is absolutely quiet*. They were all, therefore, long fermentations, which is not exactly an objectionable feature provided there is at all times an even progress from the start to the end. Other fermentations similarly conducted had very similar features and these may therefore serve as typical of the effects of prolonged

aeration being substituted for defecation with sulfur. It is not intended to recommend such a method except for the feature that no sulfur enters into the operation, which for certain purposes may be a desirable object. These cases are offered to show by comparison that the reasonable use of sulfur brings about, after all, a better fermentative development and causes less annoyance and delay in the practical work during vintage. All these as well as subsequent cases cited have resulted in wines of good keeping qualities, except where particularly noted, and the reader can therefore be assured that no wild or unmethodical experiments are brought before him for the purpose of merely illustrating a few points of pet theories. Errors of omission and commission are made in any line of work and particularly where new methods have to be adapted to the practical conditions prevailing in a locality. Such errors will be made by anyone pursuing such a course of improvement in the fermentations of our dry wines, and it is therefore not an easy matter to follow such a course to a final success; but the evident benefit accruing from it to the whole industry seems to warrant a persistent effort in that line of work. What is contained in these pages does not, therefore, lead the reader or student to immediate success because he must perform the work himself in order to acquire the many points in question for his own experience.

In order to show the meaning of a long finish of fermentations that have been aerated but not sulfured, a few examples will be given where the must was thoroughly defecated by means of sulfur. These will tend to prove that musts so treated will be acted on by the yeast more promptly and that the finish will be of shorter duration. It may appear as if the work of the yeast is more thorough in a long finish, but that contention will not stand

in the face of the fact that fully as satisfactory results were obtained from a quicker finish. Such an even progress of the fermentation has the great advantage of less exposure to the contamination of harmful germs which are always present and ready to enter the wine at any stage of the process. Besides, a quicker finish obviates the inconvenience of long waits and of a likely lack of cooperage for subsequent fermentations.

Scientific investigators have proved that fermentations do not proceed without oxygen or air. Defecated musts are deprived of air by the settling of the solids that absorbed it during the usual operations of winemaking. Besides, the yeast, though used to sulfur in its preparation, can not act promptly in the presence of much sulfurous acid which such aeration removes to some extent. Judging from the general behavior of yeast under the influence of the remaining sulfurous acid and supplied with only a limited amount of air, we may conclude that its work is more complete and thorough in the production of alcohol than with an excessive aeration and a total absence of sulfurous acid. The general effect of oxygen on the yeast cells seems to be an increased growth or propagation accompanied with a temporary cessation of their fermentative activity, as has already been mentioned. The new cells thus formed would naturally not have as great a fermentative power as the old and developed ones, but what they may lack in vigor they seem to make up in quantity or numbers. It may, therefore, be possible to estimate approximately the effects of aeration, as in cooling, by adapting it to the nature of the yeast, or its vigor at the time of its addition to the must, as well as to the composition of the must and general local conditions. Such control over apparently wilful forces would further help to establish even fermentations. These points are well worth noting in the following tables.

TABLE 4.

2400 gallons White Must. Sugar, 22°; temperature, 70° F. (In two lots.)

(1) Must run into sulfured sump; settled for 25 hours, then pumped with spray into sulfured tank and defecated for 26 hours, then pumped with spray into ferm. tank and 15 gallons yeast added.

(2) Must run into sulfured sump; settled for 23 hours, then pumped into sulfured tank and defecated for 23 hours, then pumped with spray into (1) and 15 gallons more yeast added.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
32	14	81	8	
24	7.5	88	6.5	Cooled 4 hrs. to 82°.
24	4.5	85	3	
24	1.5	88	3	
24	—0	89	1.5	
128 hrs. or 5 d. 8 hrs.				Average loss of sugar per 24 hrs., 4.1°.
31 hrs. finish till quiet.				Very fine fermentation.
6 d. 15 hrs.	max. temp. 89°		22°	Total cooling, 4 hrs.

The different nature of this fermentation needs no further comment except that the cooling was insufficient, for the temperature should have been kept within a limit of 86°. In fact, a smoother wine is produced when such limit is taken at 80°, which would have meant perhaps 8 hours of cooling. This means practically an unlimited supply of cold water at 58° or 60° F., which is indispensable for the purpose in view. The average loss of sugar per day of 4.1° indicates a good and active fermentation, and the finish of 31 hours or nearly one day and a half is quite satisfactory in point of promptness.

TABLE 5.

1300 gallons White Must. Sugar, 23°; temperature, 60° F.

Must run into sulfured sump; settled for 37 hours, then pumped with spray into sulfured tank and defecated for 24 hours; small portion of pomace started with 3 gallons yeast and added to ferm. tank after 2 days; pumped from defecating tank with spray into ferm. tank and added 15 gallons yeast.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
32	18.5	68	4.5	
24	10	82	8.5	
3				Cooled 2 hrs. to 77°.
21	5	83	5	
24	1	85	4	
24	+0	86	1	
128 hrs. or 5 d. 8 hrs.				Average loss of sugar per 24 hrs., 4.5°.
48 hrs. finish till quiet and dry (—0).				Fine fermentation.
7d., 8 hrs. max. temp. 86°			23°	Total cooling, 2 hrs.

The object of clearing the must was in this case somewhat interfered with by the addition of the juice of the fermented pomace, which also may have caused the slower action in the finish. The necessary aeration of the must after defecation consisted in spraying the must into the clean fermenting tank, which seems to furnish a sufficient supply of oxygen for the yeast. This method was followed in the previous case and has proved to be a more economical and effective one than the prolonged aeration before considered. This more limited aeration together with

the sulfuring seem to confine the yeast to its work as a fermentative agent instead of developing its vital functions of growth and increase as in the previous cases of long aerations.

TABLE 6.

500 gallons White Must. Sugar, 21.5°; temperature, 60° F.

Must run into sulfured sump; settled 1¼ hours, then pumped with spray into sulfured tank and added 4 oz. potassium bisulfite; defecated for 56 hours; very clear must; much sediment; then pumped into 600 gallon tank and added 5 gallons yeast.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
24	21	61	0.5	
24	18	69	3	
36	11	80	7	Cooled 1¼ hrs. to 72°.
12	10	76	1	
10	7	80	3	Cooled 1¼ hrs. to 73°.
26	4	77	3	
22	1	82	3	
12	—0	83	1	
166 hrs. or 6 d. 22 hrs.				Average loss of sugar per 24 hrs., 3.1°.
41 hrs. finish till quiet.				Quiet, even fermentation.
8 d. 15 hrs.	max. temp. 83°		21.5°	Total cooling, 2½ hrs.

A more complete defecation was effected here through the additional use of sulfurous acid contained in the bisulfite. There was no trace of sulfur in the wine subsequently and it has remained bright and clear since its first racking. The slower start was very likely due to the sulfur, and the longer duration of the fermentation, as compared with the previous case where the

sugar was higher, also points to its restraining influence. Of course, the slightly longer cooling (2 hours—2½ hours) and the consequent lower average temperature have a great deal to do with the length of time consumed, but it may be asserted that this was offset by the higher percentage of sugar (23°—21.5°). The initial temperatures of both were also alike (60°), but the must of the latter was a heavier one, which also induced the slower start of only 3.5° sugar lost in 48 hours as compared with 4.5° sugar lost in 32 hours in Table 5. The average loss of sugar of both (No. 6: 3.1°—No. 5: 4.5°) again indicates the true character of the fermentations.

In Table 4 the initial temperature of 70° F. plays quite a part in the quick development of the fermentative activity of the yeast; and the insufficient cooling and higher temperature shortened the duration of the fermentation. As a pattern of a nearly perfect fermentation I would choose the one of Table 6, for here we have all the conditions set forth and illustrated which are the main features of the methods advocated for the improvement of the quality of our dry wines. In the chapters on cooling and general fermentations these points will again be given attention.

With cooling pure yeast seems to have a good resistance to the effect of the excretions formed by its own action, so that the percentage of alcohol is greater than under the higher temperatures prevailing with the old methods of spontaneous or voluntary fermentations. In spite of that apparent fact pure yeast does sometimes fail to remove all the sugar from the must of red wines, either free from, or fermented on, the pomace. This may be due either to the presence of sulfurous acid, if such was employed, or to an excess of sugar in the grapes. Aeration in both cases, before fermentation in the former and during its

course in the latter, aids the yeast by removing the sulfur and by invigorating its vitality and action. The failure of red wines to ferment dry on the pomace has for its cause usually the development of additional sugar from the dried grapes which, added to the often high sugar found by the saccharometer, makes the task of a perfect fermentation impossible. In other words, the yeast is bound to become inactive and die in the presence of what may be termed its own poison, that is, from the effect of the alcohol. If the vigor of the yeast is unimpaired and an extra aeration is given the pomace at the start and during the cooling, when that becomes necessary, there is a greater probability of pulling a tank of that sort through to dryness.

Any drop in the temperature toward the end of a fermentation is always a most reliable danger signal that the yeast is through one cause or another unequal to the task given to it. It is, therefore, quite an important part of the management of fermentations to take the temperature and the sugar of each tank in action at least twice a day. Such observations form the principal records of the vintage and are essential for the better understanding of the operations when reference is made to them at some future time. We build more or less on past experiences and these should be at hand in a more dependable manner than human memory can possibly retain them. It pays to keep close watch on the progress of the fermentations and when such an observation as the decline in the final temperature is made we may often be able to revive the flagging yeast by *aeration and agitation*. The idea is not only to get the yeast cells into more thorough contact with what is left for it, or assimilable by it, in the must, but to animate them by means of the oxygen of the air. If the must is simply allowed to flow into a tub and pumped back

into the tank there may be sufficient aeration but the yeast is not stirred up enough in the must itself. Agitation, on the other hand, by means of pumping air into the must—preferably warm air—is a more effective and economic way of mixing must and yeast and giving the latter renewed energy, provided always that other influences, such as the entrance of bacteria or moulds, have not undermined that energy beyond repair. Any exposure to the air as in the case of pumping over the must is apt to invite contamination by the fungi prevalent in any cellar besides depriving the must of heat, which in such cases should be conserved rather than wasted. In order to warm the air needed the end of a suction hose can be placed close to the power boiler, but should be slightly plugged with absorbent cotton to exclude floating germs. The discharge hose is then put into the fermenting tank and placed at various points of its bottom, these being changed now and then in order to fully stir up the sediment. In the transfer the air would probably lose some heat but would reach the tank at about 80° to 85° F. On cool days this supply of warm air has proved to be remarkably effective.

In theory aeration ought to be resorted to whenever the temperature keeps dropping, especially when the sugar is still high, but in practice the "let alone" policy often induces us to wait too long and to aerate too near the end of the fermentation which is often ineffective. Let us take the case of an old method fermentation of red grapes on the pomace and note the effect of aeration without agitating the must itself. (See Table 7.)

Aeration in this instance consisted in tapping the tank and letting the must run into a tub and then pumping it through a rose nozzle which sprayed it on top of the pomace. In such an operation the temperature will decline but being high in this

case it did not materially affect the outcome. Dried grapes and a subsequent addition of sugar through them gave the yeast a hard job, and as is well known is mostly responsible for "stuck"

TABLE 7.

Red Grapes Fermented on Pomace. 23° sugar; 64° F.

Crushed and immediately added 9 gallons pure yeast; added more grapes for two days thereafter at 24° and 25° sugar; added 3 gallons yeast more; stirred up three and four times a day.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
12	22	66	1	
24	15.5	75	6.5	No cooling.
24	13.5	84	2	
24	9	89	4.5	
24	6.5	90	2.5	
3		88		Aerated over pomace
21	4	91	2.5	with rose nozzle for 1
24	2.5	90	1.5	hr.; cooled to 88°.
24	1.5	88	1	Cap sinking.
24	1	88	0.5	
24	+0	86	1	
228 hrs. or 9 d. 12 hrs.				Average loss of sugar per
24 hrs. finish	—0.	83		24 hrs., 2.63°.
10 d. 12 hrs.	max. temp. 91°		23°	

tanks of wine made in that way. Of course, a higher temperature from 94° to 98° F. would by itself cause a sluggish fermentation and a final suspension of all yeast activity. In the above case a more thorough aeration at the beginning might have induced a more vigorous fermentation, but the aeration employed

was fairly well timed. If it had consisted of *agitation* as well and the air pumped into it had been warmed as suggested the response would have been better, with the further advantage that the temperature would not have dropped as it did there.

Let us take a case of similar red grapes where an excess of sugar prevented an aeration similarly timed from having any effect on putting it through and re-fermentation on fresh pomace was the only salvation for it.

TABLE 8.

Red Grapes Fermented on Pomace. 25° sugar, 68° F.; 22° sugar, 70° F., and 25° sugar, 52° F., averaging about 24° sugar.

Crushed and immediately added pure yeast in lots of 9 gallons, 4 gallons and 4 gallons, adding grapes 15 and 25 hours after start, and then added 4 gallons yeast again, making a total of 21 gallons yeast; a day after aeration added 12 gallons more, so total amounted to 33 gallons; tank stirred up three and four times a day.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
14	20	70	5	Added grapes, 25° sugar,
24	16	86	4	52° F., which cooled
24	14	88	2	mass.
24	11	89	3	
24	8	91	3	
24	6	90	2	Aerated over pomace
3				with rose nozzle for 1
21	4	88	2	hour, added 12 gallons
3				yeast and worked into
21	3	87	1	mass.
24	2.5	86	0.5	Re-fermented on fresh
12	2	86	0.5	pomace.
218 hrs. or 9 d. 2 hrs.	max. temp. 91°		23°	

The aeration here had no visibly invigorating effect, and neither was the addition of 12 gallons of yeast of any consequence. There were more dried berries in the latter pomace and the grapes were sweeter from the start. Both were aerated practically at the same stage of sugar and temperature, but the temperature of the latter fell more quickly and there seemed little hope for a successful end. Again, a more thorough agitation by pumping warm air into the tank would have had a better effect, but whether in the presence of so much sugar the fermentation would have gone through remains an unanswered question. The use of bisulfite and of an aeration at the beginning might also have materially aided the yeast in its difficult task. It seems hardly probable, however, that even pure yeast can cope successfully with an excess of sugar in the grapes.

During one vintage some German imported yeast was used on a few tanks and proved to be too weak for our heavy California musts. In Chapter VI we shall see its action in some of those fermentations, but suffice it to say now that it was particularly slow in winding up its work so that ½° was the loss of sugar from day to day. An agitation by means of aeration with warm air caused the sugar to disappear quickly and the fermentative activity of the yeast to be revived. The effect was remarkable and induces me to recommend this method in preference to the one shown in the two tables. The latter demonstrate that it is not advisable to postpone aeration too long so that the alcohol developed does not interfere with the effect of the oxygen on the yeast cells. Any prolonged aeration will tend to oxidize the wine and cause discoloration thereby. A certain amount of air, however, entering the must at the start will not produce that effect and will help the yeast far more in its work than any subsequent aeration.

The yeast cells need oxygen for their vitality and development and hence the yeast supply used for starting the fermentations is regularly aerated three times a day to keep it in good condition. There we want the yeast cells to grow and increase in numbers so that they enter the must in a fairly mature state and are able to immediately proceed with the work of fermentation. If a further aeration of the must is employed we have seen that the result is a violent start and a slow finish, or a fermentation unsteady in its course. Furthermore, we employ aeration after defecation with sulfurous acid in order to remove to a certain extent the acid and to supply oxygen for the yeast cells. Aeration does, therefore, form an important link in the chain that binds the various operations of these methods of wine making together. Its relation to sulfuring or the use of bisulfite may be expressed best by the following two propositions:

(1) Less sulfuring and more aeration increase the violence of the fermentation and delay its finish.

(2) More sulfuring and less aeration induce an even and well balanced fermentation and its quicker finish—

It seems to lie, therefore, within the power of the operator to obtain through these two agencies a nearly perfect fermentation if he knows his varieties of grapes and their musts. A well balanced fermentation is one that is symmetrical in time, in loss of sugar and increase of temperature; that is to say, it should proceed for a longer or shorter period of time with a gradual loss of sugar and a gradual increase of temperature. As an unfailing sign of its strength and vigor we may take the rising temperature at the end. No matter how much cooling may have been done, rightly or wrongly, or what otherwise may be the

nature of the fermentation, *it should end with a rising temperature.*

Personal experience has shown me that a more or less prolonged aeration of white must from red grapes tends to eliminate the color, because such oxidation renders the latter insoluble and precipitates it. Sulfur, on the other hand, seems to fix the color more and should be used only sparingly in such cases. Any excessive aeration, however, is apt to turn the must dark or brown, and will be noticed in the wine. It has also been stated that by aeration certain albuminoids in the must are likewise rendered insoluble and precipitated, and this fact may explain in part the irregularity of the fermentations given, because it may affect the composition of the must and hence the action of the yeast.

As a general conclusion we may say that a limited supply of air in conjunction with such an amount of sulfur or sulfurous acid as will prevent or correct a possible contamination by flying germs, seems to be the most congenial condition for the development of an even and steady fermentation with a prompt finish. A limited aeration *after* defecation with sulfur for white musts—such as occurs inside of a *clean* fermenting tank by means of the spray—and a longer aeration *without* such defecation for white musts from red grapes—for a better elimination of the color—but followed by spraying into a *slightly* sulfured fermenting tank, would be about the safest course to accomplish such regular fermentations. Again, with regard to sluggish red must, fermented either on the pomace or by itself after an extraction by heating, an *aeration with agitation* or forcing cold or warm air into the mass is much to be preferred to pumping them over by tapping and spraying.

CHAPTER IV.

THE COOLING OF MUSTS AND ITS CONTROL OF FERMENTATIONS.

The temperature at which the yeast seems to develop its greatest activity is probably 85° F. and fermentations that are kept between 80° and 85° have a shorter duration as compared with those under lower temperatures. If we are intent on economy of time rather than on quality these limits are to be taken as standard temperatures; but if we do not mind longer durations, brought about by artificial cooling to lower temperatures, we are likely to have in the end a more desirable product.

Most wines made with a maximum temperature of 80° or even 78° seem to have much less fixed acidity because of the greater precipitation of tartaric acid or cream of tartar. Besides this peculiarity the presence of by-products, such as the ethereal oils and glycerine, render the wine better in aroma and in smoothness. Under certain conditions even a pronounced "fattiness" occurs in the wine, which has as one of its causes undoubtedly the lower temperatures of such fermentations.

Cooling musts during fermentation and keeping them within certain limits of temperature is often a very difficult problem because it takes much prompt attention, care and judgment. This is not to be taken as an over-valuation of the recorded observations here offered to the reader. All these data need a re-application to the conditions of other localities; and to implicitly follow these examples might lead to disappointments, but the general principles set forth will undoubtedly lead to better final

results in all localities where the fixed acid is not naturally low. Even then, however, these methods may not be inapplicable and may produce wines that are superior to those made before in the old way. That a thorough fermentation could be conducted at a low temperature seemed at first sight a doubtful proposition, but after repeated trials it can be asserted without hesitation that a low temperature is much to be preferred to a high one if our object is to realize wines of a mellow and agreeable character. It is still an open question whether low maximum temperatures like 75° F. are advisable to pursue, because inasmuch as the vigor of the yeast can not be supposed to be as reliable as it is at 80° to 85° it may happen that other undesirable bacteria, at home in a lower temperature, enter the wine at that stage when the yeast is not as active as under higher temperatures. A ready clearing of the wine may also be a direct effect of a temperature just right for the full development of the pure yeast used, and recurrent cloudiness in wines is no doubt due as much to extreme high as to extreme low temperatures in the fermentations. A favorable medium temperature seems to be 80° F. (26° C.) as the maximum for white wines, and perhaps 85° F. (29° C.) for the red wines, whether fermented on the pomace or free from it, as we shall see in the next chapter. Such limits, of course, include much lower temperatures in the fermentations, for cooling, in order to have a somewhat lasting effect, may throw the temperature down to 70° F. for a while. With a vigorous yeast as our ally a ready and quick recovery can be depended on and cooling becomes less risky than it is with a weak yeast, such as the German or imported yeast mentioned before and of which we shall have occasion to speak again.

Exclusive of the possibility of certain bacterial activity at low temperatures, such as "stringiness", the general tone of the

wine will be of a higher order, that is to say, the alcohol smell will not dominate the aroma, while the various essential oils making up the bouquet stand out more prominently. The wine seems to have a more truly vinous character and recommends itself by a very clean and smooth taste.

As long ago as 1897 Mr. Arthur P. Hayne in the bulletin No. 117 of our State University described some very interesting investigations concerning the control of temperatures by cooling; and later in 1906 Mr. Frederic T. Bioletti, the present viticulturist at the same institution, and a man combining knowledge with practical ideas, published the bulletins No. 167 and No. 174 dealing with the same subject more exhaustively. The cooler given on page 43 of bulletin No. 167 was the basis for the one adopted and constructed for the coolings herein given. It is illustrated in Fig. 3 as modified for our use at the winery near Napa.

In bulletin No. 174 Mr. Bioletti gives a detailed explanation of the plan and purpose of cooling during fermentation, which is all the more interesting and important because this valuable information was the outcome of extensive and intensive observations and data gathered abroad in Europe and Africa. Every winemaker should become familiar with the demonstrations therein offered, for I believe that this valuable information was never fully understood and appreciated in this state. It is such technical knowledge or information that we need for our "practical experience" in making better wines. It should not be beyond the ambition or the capacity of "practical" men to acquire the gist of the experiences of other countries of similar climatic conditions as our state, and adapt these to the needs of their own surroundings.

In order to bring the matter again to the attention of the reader I shall give as concise a statement of the principles and calculations involved as I am able to do, and shall also illustrate the main features of it by the records of fermentations so treated. From the outset I must warn the reader that mere guess-work will not do because it will lead only to confusion and final dissatisfaction with the whole operation. Economy of time and labor, and a possible mix-up in the cellar work, demand that the time necessary for cooling a tank be known beforehand. The amount of sugar still left, the temperature, the quantity of must, the rate of pumping and the capacity of the cooler will all have to be determined in order to arrive at any satisfactory conclusions at all. Besides these the supply of cold water is an important item, but it need not necessarily be unlimited in quantity provided it is cold enough. The cooler here illustrated has a supply of only 325 to 350 gallons per hour, that is, no more can be spared from the general water supply. An independent spring which now contributes to the cooler half of that quantity may be made to render the above mentioned amount by some improvements, for this water is at all times 58° F. (14.5° C.). Such a temperature alone increases the capacity of the cooler. A fairly exact estimate of the rate of pumping together with a good average of the number of degrees of heat thrown off in the cooler showed that about 800 gallons pumped per hour give a difference of 6° in the two end thermometers. This would mean that each gallon would lose 6° F. each hour and that the total capacity per hour of the cooler would be 4800°, or possibly even 5000° if the supply of water be slightly increased. It may appear as if faster pumping would accomplish more, but in that case the loss of heat, or the difference of the end thermometers, would be smaller. For instance, if the rate of pumping be

increased to 1200 gallons per hour the loss of heat will be perhaps 3° and therefore the capacity of the cooler only 3600°, which is smaller than under the previous rate of pumping. Again, slower pumping will increase the loss of heat and we may have with a rate of 500 gallons a loss of 8° or 9°, which would show a capacity of 4000° and 4500° per hour and this is less than under the first rate of pumping. In other words, there is a highest limit of the cooling effect of each cooler and it is necessary and important that it be found and established by close observation and careful practical tests, so that no time and energy is wasted by either too slow or too fast work in this operation. For larger cellars the figures are quite inadequate, but a water supply of 1000 gallons per hour at 58° to 60° could command a vintage of possibly 100,000 gallons of wine made according to these methods. In that case the cooler would also have to be larger, that is, the total length of pipes should be greater to get more surface for the cold water to act on.

Mr. Bioletti states in his bulletin that nearly half of the heat generated during fermentation is thrown off by radiation, that is, it is absorbed by the surrounding air. The location of the tank and its size has a good deal to do with the amount of radiation, but I have found that both in closed and open tanks in different locations (except outside the cellar where we do not ferment) the loss by radiation is considerably less, varying from 20% to 35% of the total heat emitted during fermentation. This percentage is largely a matter of location and climatic conditions at the time of the vintage and is another item to be established by local observation and continued tests. This is not a difficult matter as long as records are kept and comparisons are therefore made possible, but to go at it in a haphazard way will lead neither to intelligent understanding of the principles

involved nor to competent execution. Furthermore, when cooling is insufficient its effect on the wine will not be noticed, and when it is overdone trouble may be experienced in the fermentation.

Taking the correctness of Mr. Bioletti's figures for granted we have for each degree of sugar in the must 2.34° F. developed during fermentation. To be more exact his statement should be given that "every gram of sugar in a hundred cubic centimeters of must will during fermentation generate 2.34° F. of heat, which approximately amounts to the same for every degree of sugar in the must". In justice to his statement that radiation eliminates half of that heat it should be borne in mind that in most coolings herein discussed the maximum temperature was kept lower (80°) than in the experiments on which he bases his deductions. Instead, therefore, of taking 1.17°, or one half of 2.34°, as the amount of heat to be eliminated by cooling, I found the figures 1.50° to 1.80° as the portion of the 2.34° that had to be taken out of the must by the cooler. On the average it was nearer the latter figure than the former, and sometimes even higher when the weather was warm and still, which naturally would lessen radiation and necessitate a greater or longer cooling. The rule laid down by him that cooling, in order to be most effective in point of time and labor, should not be applied until the desired maximum of temperature is reached, is an excellent one to follow, because the higher the temperature the more heat can be eliminated in the cooler in a given time. If, however, we are intent on a low average temperature, cooling should be resorted to even before such a stage is reached, since amid the rush of the vintage we are not always able to work out such operations to a great nicety, but are often compelled to prevent high temperatures by an earlier interference.

If the reader will refer to the bulletin No. 167 he will find on page 19 the factors given in the calculation for the amount of heat developed in the must that is retained and increases the total temperature of the fermenting tank. These are again given as very valuable items in this operation.

Let

S = sugar (% Balling) contained in the must,

T = temperature of contents of vat,

M = the maximum temperature desired,

C = the numbers of degrees necessary to remove by cooling;

then

$$C = 1.17\ S + T - M.$$

Example:

$S = 24\%$; $T = 80°$ F.; $M = 92°$ F.;

then

$$C = (1.17 \times 24) + 80 - 92 = 16°\ F.$$

"In this case, therefore, it would be necessary to remove the equivalent of 16° F. from every gallon of fermenting grapes in the vat."

The original temperature of the must, therefore, plus the degrees of heat developed during fermentation and minus the degrees of heat calculated as radiation, would give us the final temperature of that tank if no cooling is resorted to; and this holds true at any stage of the fermentation when we make the same calculation based on the sugar then in the must. Let us take a must at 21° S. and 60° F. and according to my figures for a smaller radiation the final temperature of that fermentation would be found as follows:

$$60° + 1.50 \times 21 = 91.5°;$$

or with a smaller radiation still we may have it as follows:

$$60° + 1.80 \times 21 = 97.8°, \text{ or nearly } 98°.$$

Now, if it is desired to keep the temperature within 80° F. it is evident that 11.5° in the one case and 18° in the other will have to be removed by cooling. Correcting the formula given we have

$$C = 1.50\ (1.80) \times S + T - M,$$

which would read in this case

$$C = 1.50\ (1.80) \times 21 + 60 - 80 = 11.5°\ (\text{or } 18°).$$

This means that each unit or gallon will have to be cooled 11.5° or 18° to keep the whole mass within the limit of 80° F. If we have 1000 gallons of such must, then 11500° or 18000° will have to be removed from the total quantity. The capacity of this cooler being about 4800° to 5000° of heat removed per hour we can readily find the time necessary for cooling for a limit of 80° F. by dividing 11500 or 18000 by 4800 or 5000. According to the figures taken it will be:

$$\frac{11500}{4800} = 2.4 \text{ hrs. or } 2 \text{ hrs. } 24 \text{ m.}$$

$$\frac{18000}{5000} = 3.6 \text{ hrs. or } 3 \text{ hrs. } 36 \text{ m., etc.}$$

This calculation is well demonstrated in the same bulletin on page 20, as follows:

Let

H = the number of hours cooler must be used,
G = the number of gallons of grapes in the vat,
C = the number of degrees F. which the whole vat must be lowered,
R = the number of gallons per hour passed through the cooler,
F = the number of degrees lost by the wine passing through cooler;

then

$$H = \frac{G \times C}{R \times F} \text{ or } \frac{\text{Total heat to be removed}}{\text{Total heat removed per hour}} \text{ (as above given)}$$

or, as applied to above figures,

$$H = \frac{1000 \times 11.5}{800 \times 6} = 2.4 \text{ hrs. or } 2 \text{ hrs. } 24 \text{ m.}$$

On account of the heat development alcoholic fermentation was for a long time considered to be wholly a chemical process, and it is that to a great extent even though the yeast cells act as agents in the conversion of the sugar into alcohol and carbon dioxide. This breaking up of the sugar causes in itself the larger amount of the heat produced in the process, but each cell is also supposed to have a certain amount of individual heat and their aggregation in the must in large numbers does no doubt further increase the heat developed by the conversion of the sugar. From observations on the relative amount of the yeast starter it would almost seem that in cool fermentations a larger number of developed yeast cells added to the must accomplish a better fermentation than the 1% generally recommended, for at a low temperature these are less likely to yield a large crop of young cells than at higher temperatures, and they may be said to confine themselves more exclusively to their fermentative activity.

Let us now consider for a moment the simple construction of the cooler employed. From the start it will be seen that such a cooler is not suited to any locality where water is neither abundant nor cold, and the reader may gather better information regarding a cooler under such conditions in the bulletin No. 174 before mentioned. A diagram of our cooler is herewith given in Fig. 3 on the next page.

It should be stated that at both ends of the copper pipe there is a thermometer whereby the temperatures of the incoming and outgoing wine or must is registered. It may be sufficient to have only one at the outlet because the temperature of the incoming must may be taken from the tank that is being cooled, and the difference, which is the heat removed by the cooler, may therefore also be found in that manner. It is, however, more convenient to have the two end thermometers in place and to have them of

such graduation so that they are more easily and accurately read than the ordinary steam thermometers. It is quite necessary to be able to tell at any time the number of degrees which the cooler eliminates during its work. This difference in temperature is a somewhat variable quantity of which an average ought to be taken for the calculations in the formulas given or in any rough estimate which a winemaker may prefer. For, with the same rate of pumping, a must at 85° or more will throw off more heat than a must at 80°, so that the cooling at the start is always more efficient in point of degrees lost than the cooling toward the end; and if, therefore, we find this difference to be 8° at the start it is likely to be but

FIG. 3.

Length of ditches, 24 feet; width of cooler, 4 feet; total length of pipe, 175 feet; size of pipe, 1⅛ inches.

5° or less after several hours. Taking into consideration the time consumed in such gradual decline of heat lost, an average can be established for any kind of cooler. It is not meant to discourage the reader by hair-splitting calculations, but in order to get any approximate idea of the capacity of a certain cooler these observations will have to be made fairly accurate.

During a certain cooling, for instance, three observations are made as follows: 8° lost 1st hour, 7° lost 2nd hour, 6° for next ½ hour, and 5° for the last ½ hour, the average may be found roughly as follows:

$$8 \times 1 = 8$$
$$7 \times 1 = 7$$
$$6 \times \tfrac{1}{2} = 3$$
$$5 \times \tfrac{1}{2} = 2.5$$
$$(26) \qquad 4\overline{)20.5} = 5.1^\circ \text{ average loss per hour;}$$

or if the last two readings were for full hours we would have a total of 26 which divided by four would give an average of 6½° per hour, and so on.

The two factors that should not vary during such an operation of the cooler are (1) the rate of pumping and (2) the flow of water. Both of these should be fixed beforehand from close observations of various coolings in order to establish the maximum capacity of the cooler or the greatest number of degrees of heat lost per hour. If we increase either or both, another approximate estimate can be made under the new conditions and the calculations based on it. It was stated in the same bulletin that the best results in cooling were found when the flow of the must equaled the flow of the water. This would require a very large amount of water if cooling is to be done at all in reasonable limits of time, a condition that but few cellars could command; but if the water is from 58° to 60° F. the cooling is quite satis-

factory in point of time when the flow is only one half of that of the must or even a little less. Any cooler constructed on similar lines as the one illustrated can be made more effective by a longer ditch and a slight increase of water.

What appear to us, in our experience in Napa County, the principal features or characteristic results of cool fermentations are:

(1) A higher percentage of alcohol;

(2) A greater elimination of cream of tartar or tartaric acid;

(3) A better development of the desirable by-products of the pure yeast fermentation, such as glycerine and the essential oils that make up the smoothness and the aroma of the wine;

(4) Less danger from the bacteria that develop in high temperatures.

Much has been said against the alcoholic strength of our California wines, but the reason for that lay not so much in the alcohol as in its combination with other disagreeable or objectionable qualities which high temperatures certainly are apt to develop, and which are also largely caused in white wines by the omission of settling or defecating the must. The higher alcohol in cool fermentations is principally due to the fact that it does not evaporate so much as it does in warmer musts. This observation enables the winemaker to harvest his grapes somewhat sooner when they have more acid and in consequence cause less trouble in fermenting. With a relatively high acid the fermentative action of the yeast seems to be always more prompt and of shorter duration, which is always an advantage in the economy of the vintage work. Credit should also be given the pure yeast for this higher percentage of alcohol because it is more complete and thorough in its action even at lower tempera-

tures than heretofore thought advisable or feasible in the fermentations of wines. A few analyses of the alcoholic contents, together with the acids, as compared with the percentage of sugar (Balling) in the original must, may be of interest to the reader. The readings of the sugar were usually made when the must was settled and fairly clear and the temperature about 60° F. Even then a deduction of 2° or 2% should be made for the solids in the must in order to obtain the actual per cent. of sugar transformed into alcohol. The percentage of alcohol by volume (as ordinarily computed) has been calculated to be about 59% of the sugar by weight; that is to say, if the saccharometer indicates 20° or 20% it means that the sugar in the must weighs approximately 20 grams in a volume of must of 100 cubic centimeters, one cubic centimeter being the bulk of a gram of water at 39° F. If both these figures are multiplied by 10 we obtain the number of grams in 1000 cubic centimeters, which make up the volume of 1 liter. In this instance we would have 200 grams in a volume of 1000 cubic centimeters, or as it is often termed, 200 "pro mille." Free and volatile acids, as well as remnants of sugar in wines are estimated in that manner. The reader's attention is herewith called to the simplicity and directness of the relations between weights and volumes in the metrical system. Our cumbersome system of weights and measures entails an enormous amount of calculation by comparison, and should long ago have given way to this admirable decimal computation such as our monetary system is also based on. Now, it has likewise been calculated that about 17 grams of the sugar transformed into alcohol will make 1% of alcohol by volume, or 1 cubic centimeter of alcohol in a volume of 100 cubic centimeters of wine or $\frac{1}{10}$ liter. Taking as an example the last test on the following table, we see that 25° or 25% of sugar by weight gave

Table	Maximum Temp.	Average Temp.	Duration	Sugar	Alcohol by volume	Free acid gram in 100 c. c.	Volatile acid, gram in 100 c. c.
21	82°	79°	6 d. 12 hrs.	20½°	11.68%	0.53%	0.041%
22	78°	75°	6 d.	22°	13.10%	0.51%	0 06 %
24	80°	76°	7 and 8 d.	21° and 16°	11.49%	0.46%	0.053%
27 and 28	81°	77°	11 d. 12 hrs. and 8 d. 2 hrs.	21°	12.42%	0.45%	0.051%
31	83°	78°	7 d.	22° and 23°	13.34%	0.46%	0.057%
Not given	81°	73°	9 d.	25°	14.96%	0.47%	0.054%

14.96% of alcohol by volume. Applying the above correction of 2% for solids, we get approximately the same results in both calculations, namely:

(1) 25°— 2°= 23° $23 \times .59 = 13.57\%$
(2) 250 gr.— 20 gr.= 230 gr. $230 \div 17 = 13.53\%$

The increase of alcohol in this as in the other cases must be largely due to the low temperatures preventing more or less its volatilization, such as seems to prevail with higher temperatures; but it can also in part be assigned to the prompt and thorough action of vigorous pure yeast. Possibly the readings on the saccharometer were taken a little low, but even if we allow an extreme error of 1° and add it for a correction we shall still have only 14.16% and 14.12% respectively for the alcohol in that wine, showing a difference of about 0.80% in favor of these methods of winemaking. The above statements are not claimed to be quite scientifically correct in detail, but are given rather for the purpose of acquainting the general reader and practical winemaker with a few terms and figures that are of practical value and which have seldom been plainly put before him.

As regards the tartaric acid in the wines fermented at a low temperature it can be stated that our observation has invariably

been that the precipitation of cream of tartar or bitartrate of potash is relatively much larger than in high temperature fermentations; and the analyses also show a low percentage in spite of the fact that in our locality the acid naturally runs high. If from 4 to 5 grams to the litre is considered too low—for this seems to be the result in such fermentations—the remedy of earlier harvesting again presents itself to the winemaker in order to equalize to some extent the two extremes of high alcohol and low acid.

The third element that enters into the composition of such wines is smoothness to the taste and a finer aroma, that is, a cleaner and more vinous odor. Again, it should be remembered that defecation also is to be credited for eliminating the solids in the white must, and also much of the objectionable extract matter which is apt to render wines thick and heavy in body. With regard to the fattiness sometimes found in these wines, possibly due to a large amount of glycerine, there is evidence to the effect that under certain conditions its development can be brought about at will, but I am not prepared to offer an adequate cause for such a property of the wine. In fact, there is much scope for the ingenuity of each winemaker by regulating those conditions that are under his control, so that the result will be close to what he aimed to arrive at from the start. There is no mystery in all this except in so far as one man possesses a greater knack in getting such results than his neighbor. This is not exactly an indication of particular talent or of genius, but rather of great patience, dogged perseverance and capacity for intelligent work.

The danger of bacterial activity at very high temperatures has been pointed out by scientific men time and again. We also know that the yeast cells lose their fermentative power at 98° F.

and that from 85° on their vigor is gradually being impaired. When such a decline of yeast vitality takes place other germs are apt to assert their power and seriously interfere with and finally cut short the fermentative action of the yeast. Such a state of affairs is not likely to occur in low temperature fermentations, but my observations lead me to think that perhaps at certain lower temperatures there may be a possibility of other germs developing that could not grow under high temperatures. For instance, ropiness in white wines, which is said to be caused by bacteria, may be an example of such inroads by undesirable germs at low temperatures. Though such a condition of the wine is not exactly serious and can be corrected without much trouble by aeration, sulfuring and by tannin with subsequent fining, it would nevertheless be worth knowing whether by proper manipulation of the must it could be entirely avoided.

One feature of the fermentations under discussion is their longer duration, and this may appear objectionable when compared with the rush habits of the old methods where the sole anxiety was to put a tank through as soon as possible. One has to get used to this change from fast to slow fermentations, but the winemaker can be assured that there is no danger from acetic contamination provided that the yeast is of a vigorous nature and precautions are taken against too great an exposure to the action of the air. In other words, tanks with heads are preferable for that purpose, and during the latter period of the fermentation, when there is too weak a fermentative activity, these may be closed and kept under the usual pressure by inserting a syphon hose in a bung and putting the free end of it in a small vessel of water. We shall presently see how excruciatingly slow some work of the German yeast proved to be, causing in one case a high percentage of volatile acid. Owing

to the unexpected behavior of that yeast no precautions as mentioned were taken, otherwise the result would have been more favorable. This was a yeast that evidently could not assimilate or digest the heavy must it was brought into contact with. Less sugar and more acid were very likely the conditions under which it had been cultivated, and when it got into this must its task was really beyond its capacity.

Before giving a few examples the reader is again reminded of the one desirable distinction of any fermentation, be the temperature low or high, and that is a rising temperature at the very end. It is surely a sign of a well sustained fermentative activity of the yeast and can safely be considered an indication of a good and vigorous fermentation.

To illustrate the last point in question let us look at a white wine fermentation whose maximum temperature was 86° F. and ended with 79° F., as given in Table 9.

The wine would not clear well and finally acquired a pungent taste probably due to lactic acid, and it was pasteurized after six months and recovered fairly well but never was a good wine. The cause of this must have been the condition of the grapes from that neglected vineyard. In spite of a thorough defecation the moulds and fungi seemed to have been too plentiful for its effect and nearly wiped out the action of the yeast. This fermentation under normal conditions should have risen to probably 92° F. and would have required cooling. It is no advantage when in such cases we escape the work of cooling, for in this instance it meant nothing short of bacterial supremacy. It serves as a fine illustration of how important it is that we observe the development of the temperature and ascertain if the same ascends or descends toward the end, for the one indicates the success of the yeast and the other that of its enemies.

TABLE 9.

White Must. Sugar, 21°; temperature, 64° F. ¾ ton from outside vineyard and grapes in shriveled condition owing to neglect and mildew and other fungus.

Crushed and pressed and settled in sulfured defecating tank for 48 hours; **juice very clear**; total, 800 gallons; added 9 gallons pure yeast; started in 24 hours.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
16	18	70	3	
24	12	77	6	
24	9	85	3	
24	7	85	2	No cooling required.
24	5	85	2	
24	4	86	1	
10				Aerated by pumping
14	3	84	1	over for ½ hour.
24	2	84	1	
24	1.5	82	0.5	
24	0.5	82	1	
24	+0	80	0.5	
24	—0	79	..	
280 hrs. or 11 d. 16 hrs.	max. temp. 86°	21°		Average loss of sugar per 24 hrs.. 1.8°. Very quiet fermentation.

A case of a fermentation of red grapes on the pomace will further illustrate the occurrence of an apparently thorough fermentation, giving us in the end an unstable and possibly diseased wine. This must, as also the preceding one, was quite dry, but showed a distinct drop in the heat of the tank before dryness took place. Hence the great advisability to take records of the temperatures twice a day during fermentation.

TABLE 10.

Red Grapes on Pomace. Sugar, 23°; temperature, 65° F.

Crushed directly into closed tank; location of latter a little draughty; total result about 180 gallons; added 5 gallons pure yeast to pomace; stirred three to four times a day. Weather fair but not warm.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
12	in full fermentation.			
48	11	81	12	
24	6	82	5	
24	2	80	4	No cooling; nights cool.
24	0.5	74	1.5	
24	—0	72	0.5	
156 hrs. or 6 d. 12 hrs.				
6 hrs.	finish (pressed).			
6 d. 18 hrs.	max. temp. 82°		23°	Average loss of heat per 24 hrs., 3.54°.

This wine showed lactic ferments well developed eight months afterwards and was then pasteurized. The contamination may have come from the tank in which it was fermented, this being a very old one but quite sweet and clean, apparently, when used. Such ferments may possibly linger in the wood for many years and again develop under favorable conditions. It is certain that they entered the must during fermentation, whatever their origin. If the yeast had had the upper hand in this fermentation the temperature would have gone up higher than 82°, and the

sudden drop, when there was still some sugar to ferment, indicates its abating vigor under the attack of the bacteria mentioned. The low temperature was due to a draughty location and cool nights, but these conditions could not cause the final drop in temperature. It was caused by the interrupted fermentative activity of the yeast.

Let us now look into the two fermentations of the same variety of grapes but of two different vintages and where the sugar and initial temperature are nearly the same but the cooling may be held responsible for the longer duration, even though the difference between the maximum temperatures was only 3° F.

TABLE 11.

White Must. Sugar, 21°; temperature, 72° F.

Crushed and pressed and defecated in sulfured tank for 30 hours, then sprayed into ferm. tank and added 10 gallons pure yeast; total, 1100 gallons.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
10	18	74	3	
4				Cooled 2 hrs. 20m. to 74°.
20	13	77	5	
24	10	82	3	Strong and rather violent
24	3.5	89	6.5	fermentation.
24	+0	92	3.5	Average loss of sugar per
7	—0			24 hrs., 4.47°.
113 hrs. or 4 d. 17 hrs.	max temp. 92°		21°	Total cooling, 2 hrs. 20m.

White Must (same kind). Sugar, 22°; temperature, 72° F.

Crushed, pressed and defecated in sulfured tank for 26 hours, then sprayed into ferm. tank and added 30 gallons yeast; total, 2400 gallons.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
32	14	81	8	
24	7.5	88	6.5	
1				Cooled 4 hrs. to 82°.
23	4.5	85	3	
24	1.5	88	3	A good and steady fermentation.
24	—0	89	1.5	
128 hrs. or 5 d. 8 hrs.				Average loss of sugar per 24 hrs., 4.12°.
31 hrs. finish till quiet.				
6 d. 15 hrs.	max. temp. 89°		22°	Total cooling, 4 hrs.

From the averages of the loss of sugar it is evident that the later fermentation was the slower one, aside from the fact that its higher sugar would tend to a longer duration. The cooling was also better timed, being done at a higher temperature and hence more effective in point of time; for, with more than twice the quantity there was a relatively shorter cooling here than in the former case.

To what extent cooling can be carried when backed up by a vigorous yeast can be seen in the following table. Here the point that cooling prolongs the duration of the fermentation can be clearly made, for with a maximum temperature of 79° and sugar at 23° (Balling) the average loss of sugar is but 2.19° per day and it takes 10½ days in all.

TABLE 12.

White Must from Red Grapes. Sugar, 23°; temperature, 68° F. Crushed and defecated in sulfured sumps in two lots; first lot, 500 gallons, 21 hours; second lot, 300 gallons, 22½ hours, adding to latter 6 oz. bisulfite for defecation, then sprayed into ferm. tank and added 8 gallons pure yeast.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
12	..	74		Violent start.
24	15	77	8	
7	14.5	78	0.5	Cooled 4 hrs. 30m. to 66°.
17	13	67	1.5	
24	11	70	2	
24	9	75	2	
24	7	77	2	
10	6	78	1	Cooled 1 hr. to 74°.
14	5	76	1	
24	3.5	78	1.5	Average loss of sugar per
24	1.5	79	2	24 hrs., 2.19°.
24	0.5	79	1	Very fine and steady fer-
24	—0	..	0.5	mentation.
252 hrs. max. temp. 79° or 10 d. 12 hrs.			23°	Total cooling, 5 hrs. 30m.

The wine was bright and clear in two months, whereas wines made with high temperature, such as in table 11, remained turbid for a much longer period. In this case cooling down to 66° F. was no doubt excessive, for the fermentative activity of the yeast, as judged by the temperature after the cooling, did not seem to recover its full intensity. A concurrent fermentation of the same must (700 gals.) at 23° sugar and 66° F. was

cooled when at 81° for only 3 hours down to 70°. There was a quicker recovery and the temperature rose at the end to a maximum of 84°, the average temperature being 77.7°, while in the last table the latter was 75.6°. Again, the duration was 7 days 18 hours with a finish of 1 day, and the average loss of sugar per 24 hours was 2.97°. The alcohol was higher and the free acid lower than in the wine of Table 12, the volatile acid being the same in both. This would go to show that excessive cooling, though feasible, does not bring about the most favorable results.

It would appear that only heavy musts can safely be subjected to extreme cooling such as in the last case, since the yeast will find more sustenance in them; but the lighter ones can be handled in a like satisfactory manner, as we shall see in the chapter on general fermentations. When trying to keep within a limit of 80° or 79° as in the last case, a calculation based on the formulas given becomes a very necessary condition. It should be borne in mind, however, that the loss of heat by radiation at the low temperatures of the last fermentation in Table 12 is very small, and for the rough calculations during the vintage we may assume it to be almost nothing. Every degree of sugar may therefore be taken as generating 2.34° F. or the full amount of heat mentioned before. For instance, let us take the first cooling of Table 12 when the must showed 14.5° sugar and 78° F. The capacity of the cooler having been estimated at 800 gallons per hour with a loss of heat of 6° F. in the cooler, the total time necessary for cooling to keep the must within 79° F. as a final temperature would be established as follows:

$$C = 14.5 \times 2.34 + 78 - 79 = 33\ (32.93);$$

$$H = \frac{800 \times 33}{800 \times 6} = 5.5 \text{ or } 5\tfrac{1}{2} \text{ hrs.}$$

That designates the total time necessary to have the fermentation end with 79° F. as it did with the two coolings of unequal

periods. It is more advisable to split up this total time in order to avoid the extreme drop in the temperature as given. When the average temperature of a fermentation is higher than in the above case, the loss of heat by radiation will become more noticeable. The net amount of heat generated by each degree of sugar of the must will then be from 1.50° to 2.00° F., varying with the weather conditions and the location of the tank, the difference between these figures and 2.34° F. being, of course, the heat lost by radiation. When once familiar with a cooler there is little danger from overdoing the cooling, but the reader is warned not to proceed too daringly until well informed as to the conditions surrounding him.

The objection to low temperature fermentations may be raised on the score of longer duration, for it may be somewhat bothersome to have a lot of such fermentations on hand; but a study of the varieties of grapes and their musts will in time enable the winemaker to adapt his general work and cellar operations to the needs of reasonably low temperatures and fairly short durations. With such an end in view he has the means of aeration after defecation for starting up the yeast soon, or the use of sulfur and bisulfite for the purpose of giving the process an effective steadiness, by which time is also saved. All these considerations are really beyond the scope of this work, which is solely intended to give the reader the direction in which he may travel to better results in quality. The various manipulations for these operations must of necessity be matters of personal endeavor and are the outcome of the many conditions and circumstances existing in the localities where such wines are made. Any winemaker of some intelligence can work out the details much better than he can be advised, provided he keeps clearly in his mind the main features and principles of these new methods.

CHAPTER V.

THE ARTIFICIAL HEATING OF MUSTS.

In the year 1906 Mr. F. T. Bioletti issued another interesting bulletin (No. 177) about "A New Method of Making Dry Red Wine", recommending therein the use of a French machine, called the Gomot Heater, for the extraction of color and tannin by means of heating the pomace for a short period of time and treating the must thereafter like white must. It was claimed that the must, when free from the marc or pomace, could be more readily and thoroughly fermented. The process was tried at a few points in this state and then abandoned as unsatisfactory because the wines so made were said to be unstable and would not keep. Many such innovations find ready enthusiasts who in their quest for absolute success expect too much from the very start, and seem to imagine that each new method must immediately give marvelous results or else must be absolutely worthless. Though not sufficiently familiar with the data and conditions by which the experiments with this heater resulted in failure, and not wishing to recommend its use, I still feel that the process has many good points which for the general knowledge of wine-making should be incorporated in this discussion on fermentations.

This process is especially adapted to regions where the tannin and tartaric acids are too abundant, in other words, where clarets fermented on the pomace acquire too much roughness and remain harsh in taste. As with the operations explained in the previous chapters, so likewise in this one there is much practice and perseverance necessary to obtain the best possible results. With us

three successive vintages were required to realize the value of the method under certain conditions and to enable us to use it fearlessly and without any evil consequences to the wines so made. The oldest wines made by that method are in the third year and are in good condition, never having shown any deviation from the straight path of virtue which a good wine is supposed to travel during its life. Furthermore, it may be asserted that the wines so made are not only superior to those made in former years by the old method, but they also give actually indications of having better keeping qualities. No claim is here set up that fine wines can be made in that manner, because the varieties used were not such as would produce them. The locality also is not suited for clarets in general, but when it is considered that the clarets made in that way were superior to the clarets of former vintages, that fact alone is a strong enough argument in favor of the process, even though the work connected with it is somewhat complicated and laborious. The greater cost is hardly to be taken into account because that amounts to not more than ½ cent per gallon for 3000 gallon lots or thereabouts. In view of a much better article this slight increase of cost can well be borne; in fact, all these efforts to make wines of superior quality carry with them the requirements of more time and labor. Whether this extra work is worth while depends largely on the prospects and the temperament of each winemaker, but if thereby we are able to produce the best that a locality is capable of yielding and establish a reputation for well made and pleasant wines, it would be folly to ignore its benefits. A process like this, and the others discussed before, all point to an ultimate improvement, so that it seems reasonable to suppose that in *any locality*, whatever its natural limitations, such methods would bring out a higher quality than the one previously existing.

For an illustration of the Gomot Heater the reader is referred to the bulletin above mentioned. Suffice it to say that we used direct fire in its operation and found the whole process, though not easy, at least not beyond the capacity of any alert and intelligent winemaker.

In this method the rational use of bisulfite of potash is an important item because of the necessity of keeping the pomace free from the access of wild yeast germs or undesirable bacteria during the time required, not only for the crushing, but also for the heating of the grapes.

The tank into which the grapes are crushed should be provided with a wooden strainer of 10 by 6 inches in dimensions, running clear across the bottom from bunghole to rear and having cross sections running to the sides of the tank. With proper wooden clamps at the ends this strainer can be held down in its place. Fig. 4 will illustrate its position on the bottom of the tank.

The object of the strainer is to distribute the hot must quickly when it is forced through the bottom bunghole, and again to drain it quickly after it has been heated enough. While crushing the grapes from 6 to 8 oz. bisulfite should be applied to each ton of grapes. Dissolved in a little warm water the application can be more evenly and quickly made. In hot weather a little more can be put on the pomace so as to make sure of keeping away any infection

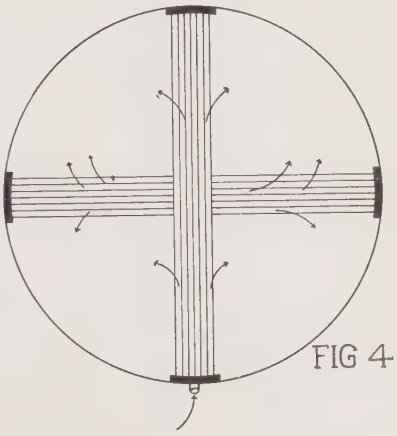


FIG 4

by floating germs or ferments. When through with crushing the must is let off into a large cement sump and from there it is pumped slowly through the heater, where it passes through a long coil of pipes immersed in hot water. By means of a thermometer the must can be kept at 175° to 180° F. At that temperature it proceeds to enter the tank at the bottom bunghole as indicated in Fig. 4 and now begins to heat up the pomace itself. A steam hose is required for conducting this hot must to the tank. The rate of pumping is about 450 gallons to 500 gallons per hour. Toward the end a man should be stationed on top of the tank where from a cross plank he can use a good poker to stir up the pomace and distribute the heat through it. The heat thus equalized through the pomace should show at the finish from 120° to 125° F. Five degrees more, or 130°, would be no detriment to the operation. The pomace is then left to itself for 6 to 10 hours, but not longer. We should be guided by the tannin, acid and color desired in the wine. Less time will give a lighter and smoother wine, while a longer exposure will render more body and color. As to the best time for heating it should be taken into consideration that the heating alone, for a tank that will yield about 2800 to 3000 gallons, will require from 6 to 7 hours. Since this part of the process requires no hard work it could be done toward evening or after supper time, if night work is not objected to, so that the pomace could be left till next morning; but the probability is that the exposure will be too long before operations are in full swing in the morning, and so it is more advisable to start heating in the morning and finish the process by night, leaving the pomace exposed to the heat no longer than 5 to 6 hours. This exposure is really enough if we do not wish to approach the old time harshness of the claret again.

The hot juice is now pumped through the cooler and returned to the sump for a *thorough aeration*, because the heating has more or less driven out the air originally in the must. Letting the juice fall from a rose nozzle suspended over the sump will effectively aerate it. Such aeration could also be done by pumping direct from the cooler into the fermenting tank, using the spray at the end of the hose, but this method is only to be resorted to when time for the other way is lacking, since it is better to give as good an aeration as possible. Pure yeast is now immediately added and the fermentation will readily start because the initial heat of the cooled must is still rather high.

The pomace that has been deprived of its liquid can either be pressed and added to the wine in fermentation, or else, if we desire to avoid excess of tannin or possible harshness, it can be fermented with some addition of fresh white must or of the must of red grapes immediately pressed. To guard against the formation of acetic acid while the hot must is being let off and before the pomace can be pressed it is very advisable to sprinkle a little more bisulfite all over the pomace and also to cover up the tank with a canvas cover just as soon as the heating is finished. These precautions are necessary because of the incessant exposure of the mass to the influence of the air and the germs floating in it. Dispatch in all these operations is the foremost condition as the heat promotes all sorts of changes injurious to the wine. The pressing of the warm pomace, aided by a little additional bisulfite, can be safely done if it is done quickly; but on the other hand it is not a bad plan to leave it unpressed and use some fresh must of white or red grapes to cool it with and then start a fermentation with pure yeast. Old wine that might benefit by a re-fermentation would also serve the purpose to make use of

the pomace. Both additions should be thoroughly stirred in and the yeast added just as soon as the temperature is low enough to present no danger to its development. Of course, such a fermentation is again the old time one on the pomace and would serve only for a lower grade wine. If the pomace must is to be kept separately it might just as well be pressed right away and fermented with some fresh must in order to avoid the long contact with the pomace of an ordinary fermentation in the tank. It seems worth while to eliminate the press juice from the main juice drawn off after heating because the difference is perceptible in the character of the wine; at least, that is our verdict after trying both methods.

In these fermentations of red musts freed from the pomace our experience has been that they proceed better under a fairly high temperature, or rather under a temperature somewhat higher than that suited for white must. It averages from 82° to 85° F. and in cooling also too great a drop at one time is inadvisable. It is hard to account for this peculiarity in the conduct of red musts, but probably there is something in their make-up that causes them to be sensitive to low temperatures. Or again, the pure yeast used may not be suited to the fermentation of red grapes and their must, for there is still much scope for scientific research in this field of the fermentative power of different kinds of pure yeast. It will also be noticed in the following table that the finish of the fermentations was rather slow as compared with others considered heretofore; which might indicate that the yeast was not quite equal to its task. Similar observations were made with red musts under similar conditions during different vintages. It were well to have a little more knowledge of the causes of such somewhat unsatisfactory signs of deficient yeast action.

TABLE 13.

Red Grapes. Average: sugar, 21°; temperature, 57° F.

Pomace heated. Weather cool; crushing and additions took nearly 4 days (white grapes crushed in between times); passed through heater from 4:30 P. M. to 10:15 P. M.; heat well distributed; final: 125° to 130° F. Next day at 7:15 A. M. must run off into large cement sump; at 12 M. pumped through cooler into 3 tanks with spray at end of hose to aerate must; final temperature, 75°; tank 1 = 850 gallons, tank 2 = 850 gallons, tank 3 = 750 gallons; added 8 gallons pure yeast to each; juice from pressed pomace added equally to each.

No. 1.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
12	19	80	2	
24	13	87	6	
3	12	88	1	Cooled 2 hrs. to 77°.
21	7	83	5	
2				Cooled 55 m. to 79°.
22	3	84	4	Good, active fermentation.
24	—0	86	3	
108 hrs.				
72 hrs. finish.				
7 d. 12 hrs.	max. temp. 87°		21°	Cooled 2 hrs. 55 m.

These three concurrent fermentations, averaging a daily loss of sugar of 4.66°, show a remarkable uniformity in duration, consuming 4½ days for the principal elimination of the sugar and taking 3 days until absolutely quiet. They will also serve as a comparative study of temperature and cooling. The last and smallest lot was not given a second cooling on the strength of its

No. 2.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
12	20	77	1	
24	13	87	7	
1				Cooled 1¾ hrs. to 75°.
23	6	84	7	
2				Cooled 45 m. to 80°.
22	1.5	86	4.5	
24	—0	88	1.5	Strong fermentation.
108 hrs. 72 hrs. finish.				
7 d. 12 hrs.	max. temp. 88°		21°	Cooled 2 hrs. 30 m.

No. 3.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
12	20	73	1	
24	17	75	3	
5	15.5	79	1.5	Cooled 1½ hrs. to 72°.
19	8	82	7.5	
24	2	90	6	Very active fermentation.
24	—0	91	2	
108 hrs. 72 hrs. finish.				
7 d. 12 hrs.	max. temp. 91°		21°	Cooled 1 hr. 30 m.

having a lower initial temperature of 73° and yet it rose too high—91° F. When quite through these tanks were all pumped together and the wine has given no trouble since, even though it

was not kept in a very cool cellar. Following this a larger amount was fermented in two lots with maximum temperatures of 82° and 84° respectively. The fermentations took about a day longer, were vigorous and required only 2 days for the finish. The must showed 21° sugar with a temperature of 70° F. The exposure to the pomace was in this case 10 hours as compared with 9 hours of the previous one.

As compared with a wine similarly made but exposed only 5 hours to the pomace the advantage of a shorter contact with heated grapes disclosed itself by a more ready clearing, a rounder and smoother taste and fully as much color. None of the wines so made ever developed any of that socalled "cooked taste" which seemed to have been one of the objections to the process. Possibly the high acidity of this locality prevents its developing, for even higher sugar of 23° and 25° has not brought it about. In our interior valleys where the acid is low and the sugar high such a taste may appear, especially when one considers the hot weather during winemaking.

The argument against the use of the heater by calling such wines "machine made" is hardly justifiable in view of the fact that they are not only a decided improvement on the quality of the wines made at the same place with the old method, but also because they are in themselves good types of lighter and pleasant clarets and possess very high keeping qualities, which latter trait deserves special mention. Their color is deeper and more permanent and the wines made separately from the pomace also showed an almost objectionable dark but rich color. After all, "the proof of the pudding lies in the eating", and whatever prejudice there may have been against this process must have come from insufficient trials and lack of perseverance or from the ill balanced composition of the grapes used. The *one great*

advantage of this process lies in the fact that the must, free from the pomace as it is, can be controlled in its fermentation by cooling. This point alone renders it possible to produce wines of greater mellowness, such as the white wines acquire when cooled in like manner. If *carefully and quickly* made the wines resulting from this process bear out all the reasoning that induced the inventor to place his machine on the market, namely, that in localities where harsh clarets prevail they can be greatly improved thereby owing to the shorter contact with the pomace. If added to this we apply cooling to the fermenting must we have another and further improvement in the quality of those formerly harsh clarets. My only object of making this process a part of this book is to add my mite to the sum total of the knowledge of winemaking, for whatever improves the quality of our wines is worthy of an impartial trial. An analysis of this wine, made eighteen months afterwards, shows the following features:

Alcohol: 13.50%—Free acid: 0.56%—Volatile acid: 0.095%—Tannin: 0.37%.

The great danger of this process will always lie in the possible greater development of volatile acid, which even in this instance is higher than it ought to be. In the reading of the saccharometer some allowance has to be made in this case for the extraction of sugar from the pomace by the heat. My notes state that the must showed scant 21°, and allowing an extreme increase of 2° after heating, though the grapes showed no dried berries, and deducting from the 23° so assumed the 2° for solids, we would again have 21° or 21% as indicating the actual sugar transformed into alcohol. As heretofore discussed 59% of that sugar would approximately give us the alcohol by volume in the resulting wine, which in this instance would show 12.39%. Tak-

ing it even at 22° we would have 12.98%; which figures leave a margin of from 1.11% to 0.52% in the actual test that can be accounted for only through the cooling and the vigorous action of the pure yeast, the general average temperature of the three fermentations being 83.5° F. (84.6°, 84.4°, 81.6°).

An experiment worth presenting consisted in heating a white must with the object of precipitating the albuminous matter or perhaps rendering the same more assimilable for the yeast. There were two concurrent fermentations of the same variety of grapes and located side by side, so that all conditions were nearly alike except that one must was heated and the other was not. By comparing their respective courses we may arrive at some conclusions regarding the merits of such a procedure. Both tanks started at the same time and were not closed up for five days, when through, in order to allow them to become quite still.

TABLE 14.

White Must. Sugar, 22°; temperature, 55° F.

Crushed and pressed into sulfured sump, then pumped into sulfured tank for defecation for 24 hours; pumped into ferm. tank with spray at end, and added 12 gallons yeast; total, 1000 gallons; cool weather.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
42	16.5	63	5.5	
24	10	71	6.5	Good light brown froth.
24	7.5	76	2.5	
2	7	78	0.5	Cooled 1 hr. to 74°.
22	4	76	3	Average loss of sugar per
24	1	78	3	day, 3.26°.
24	—0	79	1	Very fine fermentation.
162 hrs. or 6 d. 18 hrs.	max. temp. 79°		22°	Total cooling, 1 hour.

The outcome of it all was that the wine made of the heated must had more color in the end and lacked the vinous taste which the other retained. By following the progress of these fermentations as given in Table 14 we shall be able to see the general effect of that heating.

Both of these wines cleared up well in a few months, but the former proved to be of a thinner character to the taste and eventually had less body and color, which latter advantage is no doubt due to its defecation. The wine of the heated must became stringy after five months and was treated with a dose of 8 oz. of tannin. This may have affected its color and character somewhat; at any rate, after 18 months it showed more body and color and also a little hardness in taste. No sulfur was used at all but the must was allowed to settle for 24 hours, which removed much of the solid matter, though not as effectively as a proper defecation is wont to do. Besides, there was a prolonged aeration by means of the finely divided jet of the rose nozzle suspended over the sump, and that in itself caused further precipitation of solids and impurities, so that the treatment of the second must as far as settling is concerned was nearly the same as that of the first. Mention was made of the effect of the oxidation caused by long aerations, particularly the possibility of its effect on the color of the wine. The aeration here followed may have had that same consequence and was really overdone. If the heating of the must tended to render insoluble some albuminous matter and the aeration precipitated it, then the subsequent stringiness of that wine can not be ascribed to albumen in general, as is often done. We had expected a better wine from this process than the one made alongside of it by defecation, but the final results do not warrant such a verdict, and the sulfur must be given due credit for its influence on the fermentation and hence on the wine as well.

Same Kind White Must. Sugar, 21½°; temperature, 68° F.

Crushed and pressed into sump; **no sulfur used**; not defecated, but settled for 24 hours; pumped from sump through **heater** at 160°-165° and directly after that through cooler back into sump, leaving must at 84° over night, next morning showing 82°; then **aerated** with rose nozzle over sump for 1 hour 40 minutes; final temperature, 77°; then pumped through cooler into fermenting tank with final temperature at 68°; total, 1000 gallons; added 15 gallons yeast; cool weather.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
8	20	69	1.5	
24	10	81	10	
9				Cooled 1 hr. 50 m. to 77°.
15	7	82	3	Heavy dark brown froth.
1				Cooled 1 hr. 20 m. to 75°.
23	3	78	4	Average loss of sugar per
24	+0	80	3	day, 3.94°.
24	—0	79	..	Very strong fermentation.
128 hrs. or 5 d. 8 hrs.	max. temp. 82°		21.5°	Total cooling, 3 hrs. 10m. Wine stringy after 5 mos.

Absence of sulfur and much aeration caused a violent action and a quick start in the second fermentation, while in the first the regulating effect of the sulfur may be seen in the slower start and in the less violent conduct of the whole fermentation. While the initial temperature of the second (68°) was higher than that of the first (55°), the cooling took three hours, or three times as long, and the average temperature was 78.1°, against 74.4° of the first fermentation. From the loss of sugar per day it is also evident that the action of No. 2 was more intense, and while its smaller percentage of sugar would argue for a somewhat

shorter duration, the difference in time of 1 day and 10 hours is too great and must have for its cause the combined action of aeration, heating and also, perhaps, the somewhat larger amount of yeast used as a starter (15 gals.). As a further aid to a quicker fermentation the nutrients in the must may have been rendered more easily assimilable or digestible for the yeast cells by the heating. The undoubtedly greater heat development of No. 2 must have been due to a large increase of the yeast cells through aeration and the absence of sulfur, but again, the drop in temperature at the finish from 80° to 79° indicated that the fermentative activity of the yeast did not hold out as well as in the fermentation of No. 1. Stress was laid on the observation that the best fermentations end with a rising temperature, and here, also, the final temperature should at least have been 81° instead of 79°. Possibly the nutriment in the must was insufficient for the large amount of yeast developed under the conditions existing. In noting this marked difference between the two fermentations the effect of the sulfur is again pointed out as the controlling element of the first, and the reader will no doubt concede both its advantages in point of economy and its benefits as regards the quality of the wine. There was really no serious difference of quality between the two wines, but as they developed the general effect of the operations employed showed itself in the deeper color and the fuller body of No. 2.

These two comparative fermentations are, therefore, given for the purpose of presenting to the reader the usefulness of heating white must with a view of eliminating albuminous matter by heat, and in that manner to get the wine in good shape at an early age. When one considers that the wine so treated was much slower in clearing and did not stay sterilized by the heat, inasmuch as the bacteria causing stringiness developed in spite

of it, this process can not be recommended for white musts. Stringiness has been designated as merely a physical and temporary condition of a wine which by aeration, sulfuring and fining with tannin and isinglass can be readily and permanently corrected, leaving the wine none the worse for it. In any event, it is not a desirable or legitimate condition for the wine to be in and in this process it appears to be more of a physical condition than one due to the entrance of bacteria. It may also have been partly caused by the heating.

This method of a quick extraction of the principal ingredients of clarets brings the fermentation of red wines into much better control by the winemaker. Color, tannin and acid, besides other components, can be adjusted by the time of exposure, and the desired mellowness can be obtained by reasonable cooling. With proper aeration such tanks are not likely to "stick", even at a high percentage of sugar, provided always that the acid in the grapes do not fall below the normal. There is no doubt but that such wines are remarkably clean in taste and they also possess much fruitiness in their aroma; this depending, of course, upon the variety used. As we can not gather figs from thistles, so likewise will this process not turn out fine wines from ordinary grapes; but what it will do under all circumstances is to improve the product over that made of the same grapes in the old manner.

Having discussed the five main features of winemaking such as tend to increase the general qualities of the wines so made, namely, pure yeast, defecation by sulfuring, aeration, cooling, and heating, I shall now ask the reader's attention for the final chapter which treats on fermentations in general and shows the combined effects of these methods variously adjusted as circumstances permitted or conditions demanded.

CHAPTER VI.

FERMENTATIONS IN GENERAL.

Showing the Combined Effects of Pure Yeast, Defecation, Aeration, and Low Temperatures.

In the preceding chapters a few tables were given showing the more particular effects of the operation under discussion, and in order that the reader may more fully comprehend the importance of a well balanced combination of these methods and their general effects, a few of the best fermentations of various vintages will be reviewed.

Even at the risk of repeating the remarks previously made it seems advisable to call to mind again the principles underlying a good fermentation and the elements it is composed of. It adds much to the understanding of a process of that sort to divide its duration into three periods, namely,

(1) The time elapsing from the addition of the yeast to its incipient activity.

(2) The time from the start of the fermentation to the disappearance of the sugar by the saccharometer and by taste.

(3) The time from the established dryness of the wine to the final stillness of the liquid.

The first and last periods should be short, for by their briefness we can judge the vigor and activity of the yeast as well as the composition of the must, provided always that our manipulations have been correct and prompt. A slow beginning indicates some difficulty the yeast encounters in the must, such as too much sulfur or a lack of oxygen and of acid, and may also point to insufficient vitality of the yeast cells. A slow finish or wind-up,

after the saccharometer sinks to below 0° and up to the time when all commotion in the tank is at an end, shows that the yeast did not do its work efficiently as a fermentative agent during the main portion of the process but developed and grew in quantity instead. Such a long finish will generally invite the action of other bacteria, especially when the temperature falls at the same time. A rising temperature at the end is at all times a safe sign of the supremacy of the yeast. The middle period, or fermentation proper, will, of course, vary largely in duration. While a term of 4½ to 6 days has been generally considered with favor, good results as to quality can be obtained by a period of 8 to 12 days. Weather conditions and the composition of the must have a great bearing on such durations. The application of sulfur and of cooling will further influence the period of fermentation by restraining the action of the yeast, and so long as the character of such fermentation is of an even nature the time consumed is no cause of danger. The whole process, and the operations connected with it to direct and control it, is necessarily a very complex affair, but it is not past finding out by scientific researches; and it is to be hoped that still greater discoveries will be made so as to enable the winemaker to be still surer of his product.

We have seen the necessity of having the yeast in good vigorous condition, that is, to apply it when the cells are well developed. Again, we are dealing with variable compositions of the musts which in turn may call for larger or smaller additions of yeast in order to bring about a reliable fermentation. The yeast should be induced to attend to its work rather than to its development and increase, so that an even and intense, yet subdued, activity of the yeast is the result. With excessive aeration, as we have seen, the yeast develops too violent an action and exhausts itself before its work is completed. If it enters a must rich in

sugar only and lacking in other nutrients for its life, the yeast is put to a severe task and may work itself to death in trying to convert the sugar into alcohol and carbonic acid gas without being able to sustain its vitality. It is apt to become weak toward the end and its cells will shrivel up, a condition which even aeration will not overcome. In dealing with pure yeast, therefore, some study is required to avoid the causes that may bring about such exhaustion. These explanations of the observations, gathered from many days of practical work, are intended to again bring to the attention of the reader the strange activity of the yeast and to impress upon him the fact that we are dealing with very small living organisms which by proper direction and suitable surroundings are apt to do better work for us than when not thus cared for. They are in reality the socalled "Brownies" that do our work while we are asleep and we must humor them to get good or rather better results. In other words, we must try to control them and in that control seems to lie the secret of quality.

The first period of a fermentation, or the time consumed till the yeast begins its action, depends also on the temperature of the must besides on its composition and on the vigor of the yeast. A large amount of sulfurous acid will, of course, hold back the start. The yeast as prepared is accustomed to a certain amount of sulfur, but should at any time an excess of sulfur be present in the must, aeration is the only remedy to revive the numb yeast cells.

In Table 15 is offered a demonstration of a remarkable but annoying delay of that sort for which the following causes may be assigned: an overdose of sulfur, insufficient aeration, too much yeast, and cool and rainy weather. The last of these conditions is, of course, always beyond human control, but the others should

be adapted, accordingly. As it was they only intensified its retarding effect. Having added 8 gallons of yeast on the first

TABLE 15.

White Must of Red Grapes. Sugar, 20°; temperature, 60° F.

First lot of vintage. Weather Cool. Crushed, pressed and defecated 600 gallons in puncheons for 72 hours; also 400 gallons in tank for 48 hours with 4 oz. bisulfite added; pumped first lot into ferm. tank and aerated ½ hour by tapping into tub and pumping back with spray at end because of delay in start; added second lot; total, 1000 gallons; added 28 gallons pure yeast (in 4 days, as follows: 4, 2, 2, 3, 5, 3, 9 gallons).

Hours from start	Sugar	Temperature	Sugar lost	Remarks
39	18	62	2	
24	16	66	2	
24	14	70	2	
24	10	74	4	
24	8	77	2	
10	6.5	78	1.5	Cooled 1 hr. 5 m. to 74°.
14	5	76	1.5	
24	2.5	78	2.5	
24	+0	79	2.5	
24	—0	80		Not quite dry to taste.
48	dry			Quiet but strong ferm.
279 hrs.				Average loss of sugar per 24 hrs., 1.72°.
72 hrs. finish till quiet.				
14 d. 15 hrs.	max. temp. 80°		20°	Total cooling, 1 hr. 5 m.

day the remaining 20 gallons were added in the quantities given on the next three days in the hope that they would induce a ready start, but not until the first lot had been aerated did any

signs of fermentation manifest themselves. This aeration should have been applied to the second lot as well. The fermentation was active though quiet, and the cool weather made any prolonged cooling unnecessary. In spite of a slow fermentative activity in the yeast (1.72° per day) the temperature kept rising to the very end, which is always an earmark of a reliable fermentation. The large amount of yeast (3% almost) did not increase the action of the tank, as erroneously expected. In fact, I am inclined to think and infer from similar experiences that it will cause a delay and prolong the whole duration, because the superabundant yeast cells will exhaust the nutriment in the must other than the sugar and through consequent lack of strength will lose their fermentative power to a large extent. Crowded in close quarters, so to speak, their individual development is hampered also, so that in spite of a very vigorous yeast at the beginning we observe its weakened condition in the long drawn out finish.

Nothing seems, therefore, to be gained by excessive amounts of yeast being added for the purpose of increasing the action of a fermentation, and a very safe standard quantity seems to be the one percent. mentioned heretofore. If the sugar is high more can be added with good results than when it is low and the acid is relatively high, as seems to have been the case with this fermentation. It is quite important that the quantity of the starter should suit the composition of the must, and this is a matter to be determined by the winemaker from local conditions and from the experience with various grapes and under various circumstances. Experiments with yeasts made by scientists seem to have proved that the yeast is most effective as a starter when it is taken not at its highest state of activity, but rather when it has somewhat subsided. Such condition obtains, as before men-

tioned, when it shows about 10° sugar and has a temperature of 75° to 80° F. Too small a starter would induce the yeast cells to multiply rather than to attend to the work of fermentation, especially when the temperature of the must is high. In that case we are likely to have also a slow start. Again, red musts, whether on the pomace or free from it, seem to require a relatively larger amount of yeast, according to my observations, than white musts. Variations in the seasons, and consequently also in the composition of the musts, are responsible for much of the variation in the fermentations, and only by keeping records of their behavior and by employing the methods here discussed can we hope to have an approximate uniformity in the quality of successive seasons. Science has been an important guide in all industries and its principles, whenever applicable to practice, form their mainstay, but with all these there is particularly in winemaking a wide scope for art, which consists of the skill, judgment and talent of the winemaker.

With certain kinds of grapes a more turbulent fermentation seems to prevail which may be termed "boiling", because the must in action looks like a boiling caldron and has but little froth on the surface. This same feature has been observed when the starter is relatively small or less than 1% of the quantity of must. We have been unable to assign any particular cause for such a phenomenon, but it seems to indicate a large increase of the yeast cells, together with a superabundance of nutriment in the must for the yeast. In such fermentations there seems to be a prompt and almost violent start but rather a slow finish. Let us take, for instance, a similar lot of grapes as in Table 15 but started with a German yeast that proved to be rather weak in its fermentative action throughout its trial on various musts.

TABLE 16.

White Must from Red Grapes. Sugar, 21½°; temperature, 62°.

Crushed, pressed and run into sulfured sump in two lots: (1) added 4 oz. bisulfite and defecated for 38 hours; (2) 4 oz. bisulfite added and defecated for 26 hours. Weather warm and dry. Pumped together with spray at end; total, 900 gallons; added 6 gallons German or Zeltinger yeast; going well after 32 hours.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
12	19.5	66	2	Big froth and violent fermentation.
24	14	78	5.5	Boiling up.
7	11.5	81	2.5	Cooled 4 hrs. 20m. to 67°.
17	9	71	2.5	Boiling with no froth.
24	5	76	4	Quieter with good froth.
24	2.5	79	2.5	Going slowly.
24	1	80	1.5	Big fluffy froth.
24	0.5	80	0.5	Going well.
24	—0	80	0.5	Pumped warm air into tank for 15 minutes; active afterwards.
24	—0	80		Quite dry to taste.
204 hrs. or 8 d. 12 hrs.				Average loss of sugar per day, 2.53°.
72 hrs. finish.		78		
11 d. 12 hrs.	max. temp. 81°		21.5°	Cooled 4 hrs. 20 min.

Here we have a cool fermentation of well defecated must with a violent start at rather low temperatures. Warm weather favored the action of a weak yeast but the finish was very slow. Aeration at the end revived the yeast very considerably, as was

asserted would be the case when aeration was discussed. The air pumped in being somewhat warmed there was no fall in the temperature as is likely to happen when mere pumping over is done. The violence of the start can not be ascribed to any over-aeration after defecation such as we found to be the case in a previous chapter. It is therefore more likely to be due to the great vigor of the yeast and its small quantity which favored its growth and increase in that must.

In another fermentation of a white must of a different character this boiling appeared at the end. This case is interesting as it brings out other features of the methods here employed, particularly the use of bisulfite. It was applied in rather too large quantities because operations were somewhat delayed through one cause or another, as sometimes happens during vintage. The amount of yeast added was relatively small, being 17 gallons for 2900 gallons of must, but the fermentation was remarkably prompt, of short duration, and wound up quickly.

The must was of medium weight or gravity, being by no means from a watery kind of grapes, and yet the smaller starter of yeast was very effective in this case. The defecations were all well carried out, though the amount of sulfurous acid absorbed was somewhat excessive, inasmuch as the wine acquired a slight odor of sulfuretted hydrogen, which, however, a treatment of aeration and sulfuring later on completely removed. The weather being warm it was thought best to check every possible fermentation during the delayed operations by the use of bisulfite, but no doubt the grapes themselves also added their quota of sulfur which had been used in the vineyard. At any rate, there was evidence of too much sulfur, but nevertheless it is notable to have so prompt a fermentation under such conditions, showing as it does that pure yeast used to sulfur will often proceed undis-

mayed by its presence. The boiling toward the end indicates a sustained vigor of the yeast, which was favored much by the fine weather conditions then prevailing. The addition of more must

TABLE 17.

White Must. Sugar, 21°; temperature, 62° (averages).

Crushed, pressed and defecated in sulfured sumps and tanks in various lots for 46, 22, 23 and 27 hours; added them to vat successively in 3 days; added 12 gallons yeast at first and then 5 gallons more on second day; total, 2900 gallons; also added 4 lbs. or 64 oz. bisulfite in 8 oz. doses while crushing and defecating, or 2.2 oz. to 100 gallons; fermentation starts 3 days from very first crushing.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
42	12.5	80	8.5	Good light brown froth.
	..	..	..	Cooled 3 hrs. 15 m. to 75° (2000 gals.)
4	(13.5	71)		Added 900 gallons more must at 20°-60°.
20	8	80	4.5	
1	..	..	..	Cooled 5 hrs. to 74°.
11	6	75	2	
12	3.5	78	2.5	Boiling up.
24	+0	82	3.5	Boiling up.
24	—0	83	..	Quiet and dry to taste.
				Average daily loss of sugar, 3.56°.
138 hrs.				
or 5 d. 18 hrs.	max. temp. 83°		21°	Total cooling, 8 hrs. 15m.

after 46 hours helped to cool the whole mass and reduced the total cooling that would have been necessary, so that only 8 hours were required to keep the temperature within 83° F. The wine

was bright and clear in two months and very clean in taste and besides had the characteristic of defecated wines in being very light in color. The average daily loss of sugar (3.56°) shows a very energetic fermentation, especially when we consider the very prompt finish which consumed practically no time. The average of the previous table showed 2.53°, which is not a bad showing for any fermentation, but with such a laborious finish it does not compare favorably with the last case.

Eighteen months afterwards an analysis of this wine gave the following results: Alcohol, 12.80%; free acid, 0.55%; volatile acid, 0.078%. The usual deduction of 2° for solids would give 19° or 19% as the sugar transformed into alcohol, and this being multiplied by 59% would show 11.21% as the approximate percent. of alcohol by volume in the wine, leaving a surplus of 1.59% to be accounted for. The reading of the saccharometer was carefully done more than once and when the must was fairly clear. Even an extreme correction of 1°, making the sugar 22°, would still leave a margin of 1% of alcohol. The average temperature of the fermentation was 78.4° F., which would rather prevent the volatilization of the alcohol; but again, it would seem as if the absence of froth or cap and the boiling up of the must would favor such evaporation. Judging from this result and others we may therefore safely assert again that the cooling and a vigorous yeast are responsible for the higher alcoholic contents of the wine.

We shall now look into a fermentation of the latter part of a season when the weather was cooler and which occurred in a must of first crop grapes with an addition of second crop. Judging from the sugar (18½°) and the second crop, the acid, though not ascertained, must have been relatively high. A large amount of yeast was added because the season was at an end and it had

to be discarded. Bisulfite was used and a very low temperature kept in order to find out the resistance of the yeast to its influence. Considering the nature of the must by itself the duration of the fermentation proved to be unusually long—9½ days.

TABLE 18.

White Must. Sugar, 18.5°; temperature, 64°.

Crushed, pressed and defecated in sulfured sump for 43 hours; added 12 oz. bisulfite in 2 and 4 oz. doses; pumped into tank with spray at end and added 10 gallons yeast (20 gallons later); total, 850 gallons; started to ferment in 9 hours.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
12	17.5	66	1	Rather violent start.
24	14	72	3.5	Subsiding.
1	..	..	..	Added 20 gals. yeast.
7	12	75	2	Cooled 2½ hrs. to 69°.
16	10	71	2	Cold weather.
10	9	73	1	Cooled 2 hrs. 10m. to 67°.
14	7.5	69	1.5	Strong but gentle ferm.
24	5	73	2.5	
24	2	77	3	
24	+0	80	2	
24	—0	81	..	
180 hrs. or 7 d. 12 hrs. 48 hrs. finish.				Tastes dry; average loss of sugar per 24 hrs., 2.46°.
9 d. 12 hrs.	max. temp. 81°		18.5°	Total cooling, 4 hrs. 40m.

Granting that it takes longer to cool at low temperatures, yet with a final maximum temperature of 81° the total period of

cooling remains a comparatively long one. This fact suggests that the fermentative activity of the yeast must have been very vigorous; and there is no doubt but that the relatively long duration is largely due to the excessive amount of yeast added, as was also noticed in Table 15. We have here also a long finish of 48 hours. The greater acid in the last case aided in shortening the duration of the fermentation, which again was counteracted by the sulfur in the must. To sum up, we may assert that without so large an addition of yeast, without the use of sulfur and with the cooling omitted, such a fermentation of a light must would probably have lasted from four to five days. A concurrent fermentation of second crop grapes only will show us in the next table how, with less yeast and with a higher maximum temperature, though with proportionately the same amount of sulfur, the duration was very much shorter. (See Table 19.)

While in Table 18 we had a 3½% yeast starter, we have here a little over 2%, and the amounts of bisulfite are nearly in proportion, that is the 12 oz. for 850 gals. corresponds to the 8 oz. for 550 gals. The initial temperature was 3° more and this, with the aeration of the second lot, gave the yeast greater life from the start. These fermentations started practically on the same day, and therefore had identically the same weather conditions. The yeast supply was discarded when the additions were made and this accounts for the rather large starters, as before mentioned. The yeast was kept in two tubs and seemed to be of equal vigor, though a possible difference in vigor and development might account somewhat for the character of the two fermentations. The cooling was shorter and as effective because the temperature was allowed to rise higher, whereas in Table 18 it was done at lower temperatures and therefore required more time. No doubt the extreme minima of tempera-

TABLE 19.

White Must. Mixed second crop. Sugar, 19°; temperature, 67°. Crushed, pressed and defecated in sulfured sump in two lots: (1) for 18½ hours with 4 oz. bisulfite, (2) for 12½ hours with 4 oz. bisulfite. Pumped (1) into ferm. tank with spray at end and added 6 gallons yeast; **aerated (2) for 15 minutes** with rose nozzle over sump, then pumped into same tank and added 6 gallons more yeast; total 550 gallons; 12 gallons yeast; 12 hours from addition of first yeast tank in fermentation.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
36	16	69	3	
12	12	78	4	Boiling up.
12	5.5	84	6.5	Cooled 1 hr. 30 m. to 73°.
12	2	78	3.5	Lively fermentation.
12	+0	80	2	Subsiding.
12	—0	81	..	Dry and through.
96 hrs. or 4 days.				Average loss of sugar per 24 hrs., 4.75°.
	max. temp. 84°		19°	Total cooling, 1 hr. 30 m.

tures produced by cooling (67° and 69°) had their effect on the activity of the yeast and helped to make the duration longer.

From these comparisons we may gather the following factors which aided the fermentation of Table 19:

(1) Greater initial and maximum temperatures.
(2) Greater aeration of the must.
(3) Higher minimum temperature.
(4) Less cooling.
(5) Smaller amount of yeast.

Aside from the difference in the composition of the musts—the latter being no doubt lighter and richer in acid—these fermentations indicate the influences by which the character and especially the duration may be controlled by the means given the winemaker with these methods, so that he may after some experience be able to accomplish definite results.

Another fermentation of a light must may serve as an illustration of the combined effects of bisulfite and cooling. A much larger quantity of must (2800 gals.) is here started with 40 gals. of yeast (about 1½%) and during the two days of crushing, pressing and defecating—the first lot having been started 36 hours from the beginning—bisulfite was used to the extent of about 2¾ oz. to 100 gals. on the average besides the covered sumps and defecating tanks being slightly sulfured. The wine proved to be one of the best and lightest ever made and was bright and clear in two months. In spite of the low sugar the fermentation lasted 8 days. (See Table 20.)

The fermentations here brought to the attention of the reader were, on the average, never subjected to the influence of extremely hot weather, such as often prevails in the valleys and further inland. During the last fermentation the thermometer may have shown from 70° to 75° F. at noon, so that the grapes kept fairly cool. The greater part came in during the morning and had the advantage of the cool nights with which our socalled Bay Counties are blessed.

We have in Table 20 a fermentation showing the retarding effect of the bisulfite to the extent that it took 72 hours for even so light a must to get started after the yeast had been added. This was followed by a loss of 5° of sugar in 24 hours, raising the temperature 10°. The initial temperature of the must (57°) enabled us to keep the maximum temperature quite low. The

turbulence noticed at first subsided and the very desirable intense movement began to show itself with a light and clean froth as a cap. If it had not been for the sulfur it would have been more difficult, even with the same amount of cooling, to

TABLE 20.

White Must. Sugar, 18°; temperature, 57° (general average) (weather comparatively cool).

Crushed, pressed and defecated two days in two lots: (1) defecated 32 hours, (2) defecated 21 hours, using bisulfite at the rate of 2¾ oz. per 100 gallons; defecated in sulfured tanks with spray at end; pumped into ferm. tank with spray at end and added 40 gallons yeast; total 2800 gallons; yeast starts after 36 hours.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
72	17·	60	1	Very slow start due to sulfur.
24	12	70	5	Booming fermentation.
6	10	73	2	Cooled 5 hrs. 20m. to 69°.
18	6.5	72	3.5	Good white froth.
7	5.5	75	1	Cooled 3 hrs. 10m. to 72°.
17	2	75	3.5	Strong fermentation.
24	—0	79	2	Quite dry but going still.
168 hrs. or 7 days. 24 hrs. till quiet.				Average temperature 72° Average loss of sugar per 24 hrs., 2.57°.
8 days.	max. temp. 79°		18°	Total cooling, 8 hrs. 30m.

An analysis made eighteen months afterwards showed the following results:

Alcohol, 10.60%; Free acid, 0.517%; Volatile acid, 0.054%.

maintain the same intensity of action, and a similar violence as develops under aeration and the absence of sulfur would have been noticed. Here again the cooling was resorted to when the temperatures were low and therefore a longer time was taken up with it. Less sulfite and less yeast might be pointed out as a correction of the above case, but on the whole its course was straight and even and its duration a good average one, especially when we take into consideration that the object was to maintain a low temperature throughout.

Two other fermentations will give an insight into the fermentative activity of the yeast when seemingly the weather conditions would tend to diminish it. One of these occurred in a closed tank—like all the cases heretofore given—and the other proceeded in an open tank exposed somewhat to draughts. In both cases, however, aeration was employed to a greater extent than with the usual kind inside of a tank.

Here again a much quicker start is obtained owing to the smaller amount of sulfur used and also on account of the prolonged aeration of the third lot of must. The yeast, too, is less than 1% or nearly one half of the amount used in Table 20, and the sugar is eliminated more quickly from the very start, showing 14.5° for 72 hours, while in the previous case there was only 1° worked out with 5° in the next 24 hours. There was no marked difference in the temperature of the weather, in fact, it was cool and windy during the latter fermentation. Granting that the higher sugar in Table 21 (20.5°), as against 18° in Table 20, is likely to cause a greater fermentative activity, which may be measured by the 60% greater average loss of sugar in 24 hours (4.10–2.57=1.53), this fact alone would not account for the intensity of the fermentation, requiring also, as it did, a longer cooling, and ending even then with a higher maximum

temperature. We must, therefore, assume that the cause for the quicker development and the shorter duration of the fermenta-

TABLE 21.

White Must. Sugar, 20.5°; temperature, 61°.

Crushed, pressed and defecated in 2½ days in three lots in sulfured sumps, using 24 oz. bisulfite or about 8/10 oz. per 100 gallons, in doses of 2 and 4 oz.; (1) defecated for 22 hours; (2) 18 hours; (3) 17 hours; pumped into fermenting tank **with spray at end** for 1 and 2, but 3 being **aerated over sump with rose for ½ hour,** and then added 12 gallons yeast to (1) and 10 gallons more to (2), or a total of 22 gallons yeast; total, 2900 gallons in ferm. tank; started about 20 hours after yeast was added.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
48	12	76	8.5	Good firm froth on top.
1	11.5	78	0.5	Cooled 1 hr. 45 m.
3	..	..	..	Continued cooling for 4 hrs. to 74°.
20	6	81	5.5	Strong fermentation but not violent.
..	..	..	..	Cooled again for 6 hrs. 35 m. to 74°.
24	1.5	78	4.5	Firm froth on top.
24	—0	82	1.5	Through and dry but still going.
120 hrs. or 5 d. 36 hrs. finish.				Average temperature 79° Average loss of sugar per 24 hrs., 4.1°.
6 d. 12 hrs.	max. temp. 82°		20.5°	Total cooling, 12 hours 10 m.

tion of Table 21 lies largely in the four features varying from like ones in Table 20, namely:

(1) Greater aeration.
(2) Less bisulfite.
(3) Smaller amount of yeast.
(4) Higher average temperature.

It should also be noted that the variety of grapes was the same in each case, so that the true composition of the must was approximately the same even though the wines were made in two successive seasons but with very similar weather conditions prevailing.

TABLE 22.

White Must. Sugar, 22°; temperature, 60°.

Crushed, pressed and defecated in sulfured sump for 27 hours; added 10 oz. bisulfite in 2 and 4 oz. doses; pumped out into **open tank with spray suspended over same**, aerating the must about 20 minutes; added 15 gallons yeast; total, 1150 gallons; started about 20 hours after yeast was added.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
24	19	62	3	Good action and froth.
24	12.5	76	6.5	
3	11.5	78	1	Cooled 5 hrs. 30m. to 71°.
21	6	77	5.5	Firm and strong ferment.
4	5	77	1	Cooled 1 hr. 45 m. to 74°.
20	1.5	78	3.5	Night cold, 46°.
24	—0	78	1.5	Through but still active.
120 hrs. or 5 d.				Average loss of sugar per 24 hrs., 4.4°.
24 hrs. finish.				
6 days.	max. temp. 78°		22°	Total cooling, 7 hrs. 15m.

The two fermentations of Tables 21 and 22 started and ended on nearly the same days and the musts were of the same variety of grapes, the sugar being a little higher in the latter instance. In spite of a draughty location and cool nights and further cooling to the extent of 7 hours and 15 minutes, the fermentative activity of the yeast was even higher (4.4°) than in the previous case (4.1°), proving conclusively the vigor of the yeast cells. *It also demonstrates that even under such conditions as the open tank and the exposure to draughts and cold nights, cooling must be employed if a low temperature is to be maintained.* The heat lost by radiation is not nearly as great as is supposed to be the case, and the contention that white wines so fermented need no attention, even when cool fermentations are aimed at, will be recognized as quite erroneous.

The sulfur used in this case is practically the same in amount as in Table 21, but the aeration employed was more thorough because it affected the whole mass, while in the preceding case only a portion was aerated. Again, the amount of yeast used in Table 22 was about 73% more than that in Table 21, the percentages being about 1.3% and .75% respectively, while 1.4% was the amount used as a starter in Table 20. The greater amount of yeast with the longer aeration brought about a very prompt and active fermentation from the start, which was increased in intensity by the larger percentage of sugar in the must, for during the first 72 hours 16° sugar were consumed by the yeast. Moreover, the duration was not only actually but also relatively shorter than that of Table 21 in spite of the fact that the maximum temperature was 4° lower (82°—78°), and we may assign

as the causes of the differences between this and the previous fermentation the following items:

(1) Greater aeration, aiding the larger amount of yeast in the development of its vigor.

(2) More sugar, causing an intenser activity of the yeast.

There is no doubt but what the yeast, when thus reasonably treated with bisulfite and also aerated to some extent, does much steadier and intenser work under low temperatures as here illustrated. There is also reason to believe, from the results so obtained, that under such conditions the yeast will attend to its *work* rather than to its *growth and increase*, which is always favored by high temperatures. A distinction should at all times be made between an *intense* and a *violent* fermentation, there being in the first a low and dense froth with little or no commotion in the body of the liquid, such as "boiling", while in the latter the froth is generally loose and shows large bubbles accompanied by much agitation and a swaying surface.

The use of bisulfite or burning sulfur, when carried on in moderation leaves no perceptible consequences in the wine and neither the senses nor an analysis will be able to discover any objectionable or deleterious trace of it. That kind of sulfuring is much to be preferred to the liberal sulfuring of made wines in an older stage of development which is apt to leave the wine dry and hard. Such overdosing can hardly ever occur in the manipulations of the musts if we try hard to use no more than seems necessary for the temporary preservation of liquids so readily invaded by floating ferments. The sediments of the defecated musts contain much of the sulfurous acid absorbed during settling, but by discarding these and giving them a separate fermentation we can eliminate nearly all of the sulfur introduced from the must. What remains will pass off during

fermentation and the wine will remain soft and smooth. An analysis of a lot of sediment wine fermented by itself, together with an outline of the fermentation, appears in

TABLE 23.

Sediment of Musts, after being treated with sulfur fumes and bisulfite, and also last changes of presses.

Fermented in a cement sump of about 1900 gallons capacity and started with pure yeast but otherwise left to itself; covered up with canvas toward end of fermentation; good, steady action throughout, though sediments were being continually added for five to six days from start.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
4 d. or 96 hrs.	13	66	9	Sugar averaged perhaps 22°.
24	9	66	4	Radiation of heat noticeable.
36	2.5	69	6.5	
12	1.5	70	1	Going steadily.
24	—0	72	1.5	Tastes quite dry.
196 hrs. or 8 d.				Average loss of sugar per day about 2.75°.
7 hrs. pumped out.				
8 d. 7 hrs.	max. temp. 72°		22°	No cooling necessary.

This is a very remarkable fermentation as far as temperature, amount of bisulfite, and its duration are concerned. Being the first fermentation in that cement pit the loss of heat by radiation or absorption took place more readily than if it had been used continually for that purpose.

It is a unique instance of an intense though subdued fermentative action in a comparatively very low temperature. The

average loss of sugar per day indicates that the yeast remained vigorous and did its work steadily to the end. From the nature of the fermentation—there was no froth and no boiling up—I am convinced that by means of the sulfur and the low temperature the yeast was restrained from increasing in the must to any such extent as in previous fermentations, and therefore the original yeast cells confined themselves more exclusively to the task of converting the sugar into alcohol. An analysis showed that the amount of sulfurous acid was slightly in excess of the Government limit (0.0375%) showing the presence of 0.0384% of sulfur dioxide. The wine had rather a disagreeable odor in consequence, but by aeration and other manipulations this odor gradually vanished. It was low in acid and soft in taste and kept well, though it can not be considered in any way a fine wine because it has no aroma and too much color and body.

A similar result from the sediments of various white musts was obtained at the end of another season. Owing to more continuous additions the duration was from 12 to 13 days, in fact must was thrown into the sump when the sugar showed 0° and the temperature was 74° F., and yet it got perfectly dry in that time. The same odor, though less disagreeable, also developed in this lot, but an immediate aeration over the sump of 1½ hour sufficed to eliminate it completely. It disclosed, however, a good deal of extract flavor and like its predecessor has only a faint, if any, aroma. Its color, as may be expected, was dark, which is, of course, always objectionable in white wines. An analysis showed the following:

Alcohol.....11.64%
Free acid..... 0.44 grams per 100 c. c or 4.4 pro mille or litre
Volatile acid.. 0.048 grams per 100 c. c. or .48 pro mille or litre

As in the former case the wine is very soft in taste and has cleared well, but also does not approach the wines, from whose sediment it is made, in fineness or quality. By careful treatment such wines may be made into a smooth and drinkable beverage of ordinary character. The quality, or rather the absence of it, described and found in these sediment wines, goes to prove that what is thus eliminated from the original wines must and does diminish the quality of the latter if it is not so removed, and that such separation is a distinct advantage from every point of view.

In Table 17 the outcome of the fermentation showed the presence of a disagreeable odor of sulfuretted hydrogen which we attributed to an overdose of bisulfite, but it has been authoritatively stated that such a condition is caused by the action of the yeast on free sulfur, such as would get into the must through the grapes or through volatilized sulfur when it is burned to obtain sulfurous acid gas. The grapes in that case came from a part of the vineyard that is generally sulfured pretty liberally to avoid mildew. Possibly dew or rainwater on the berries or bunches may aggravate matters, but sulfurous acid or bisulfite, even when applied to excess, are not responsible for that particular odor, though they are apt to impart also an unpleasant odor of a different nature. Both of such conditions are, however, temporary and will disappear in time with judicious aeration and other familiar manipulations.

In the application of these methods a winemaker is continually called upon to be on the alert and to adjust the operations to the weather conditions and the composition of the must. The demonstrations here offered may not always be as conclusive and complete as desired, but they at least indicate the effects of the combinations at our command and may serve as a guide to greater perfection, which can be gained only through error and by continual effort.

Two concurrent fermentations are now offered with a view of comparing their action under different influences, though both had practically the same kind of must, except that the second one was lower in sugar through the addition of more of the lighter kind of grapes.

TABLE 24.

No. 1.

White Must. Sugar, 21°; temperature, 62°.

Crushed, pressed and defecated in sulfured sump for 31 hours; **used no bisulfite**; pumped below into ferm. tank with spray at end; added 11 gallons yeast; total, 1050 gallons; started 24 hours after addition of yeast; small lot fermented on pomace 45 hours and added to tank after being pressed.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
24	18.5	66	2.5	Going well.
24	10	79	8.5	
3	..	..	..	Cooled 2½ hrs. to 72°.
21	4	77	6	
8	3	80	1	
3	..	..	..	Cooled 1¼ hrs. to 75°.
13	1	77	2	Strong fermentation.
24	+0	78	1	*Boiling up.*
24	—0	76	..	Going still but tastes dry.
144 hrs. or 6 d. 24 hrs. finish.				Average temperature, 75.8° F. Average loss of sugar per 24 hrs., 3.5°.
Total: 7 d.	max. temp. 80°		21°	Total cooling, 3¾ hrs.

No. 2.

White Must. Sugar, 16°; temperature, 64°.

Crushed, pressed and defecated in sulfured sump for 35 hours; **added 28 oz. bisulfite** in 4 and 8 oz. doses, or about 2.8 oz. to 100 gallons; pumped below into ferm. tank with spray at end; added 15 gallons yeast; total, 1000 gallons; started 24 hours after addition of yeast.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
24	15	66	1	Going well.
24	10	75	5	
24	5.5	80	4.5	Cooled 1 hr. 40 m. to 73°.
24	2	77	3.5	Strong fermentation.
24	0.5	78	1.5	
24	+0	78	0.5	Going still; tastes full.
24	—0	77	..	Dry.
168 hrs. or 7 d.				Average temperature, 76.1° F.
24 hrs. finish.				Average loss of sugar per 24 hrs., 2.28°.
Total: 8 d.	max. temp. 80°		16°	Total cooling, 1 hr. 40 m.

Owing to threatening weather the grapes used in second part of Table 24 had to be taken in, for it was a case of losing them or making the best of a bad bargain as far as the low sugar was concerned. That, however, does in no wise spoil the comparison of the fermentations. We have here a longer duration in the must with 5° sugar less in the second lot than in the first lot. The maximum temperature is the same in each case, but the cooling was about 2 hours longer in the must with the higher sugar, which is quite natural because of the consequent greater development of heat. The average loss of sugar per day points

to a greater fermentative action of the yeast in the first case. The must of 16° sugar could not furnish the yeast an abundance of nutriment, especially when a comparatively large amount of it was used (1½%). This in itself would retard the fermentation to some degree, though a relatively high acid will aid its development and shorten its duration. In both cases the finish was prompt and that would indicate a strong vitality in the yeast. In fact, the *intensity* of the second fermentation appeared to be relatively as great as the first, which may have been caused by the larger amount of yeast used; but its greater *regularity* was undoubtedly the work of the bisulfite. The elimination of the sugar took place more evenly and there was no *boiling up* as in the other case. This restraint by the bisulfite seems, therefore, to have been the main cause of the longer duration, though the poor quality of the must and the large amount of yeast contributed their share.

In the chapter on heating musts by the Gomot Heater the reader may have observed that the yeast acted very promptly soon after having been added. The reason for that lay in three conditions favorable for the development and activity of the yeast cells, namely:

(1) the higher temperature of the must;
(2) a thorough aeration;
(3) nutriment better prepared by heating.

Table 25 gives another fermentation of that process. There were some rather irregular additions to the fermenting must after it had started, the first of which raised it somewhat in sugar as a whole, while the second increased the sugar at that stage and also cooled the mass. The latter addition was a risky one and is responsible for the rather long finish; but it lessened the total time of cooling that would have been necessary over and above the 8 hours employed and thus formed a bit of economy

that counts when the rush is on. The whole fermentation was remarkably prompt and intense and finished well. It seems as if the heating brings about a better assimilation by the yeast cells of the nutriment that they need for their vitality and activity. The bisulfite seems to be driven out of the pomace by the heat, because there is no evidence of its restraining influence in this or similar fermentations. Hence the sudden beginning and the large average loss of sugar for each day (4.2° to 4.4°).

TABLE 25.

Red Must. Gomot Heater used to extract color, tannin, etc., for 10 hours; after cooling and aerating showed 21° sugar; temperature, 70°.

Used at various times 52 oz. bisulfite or about 2 oz. for 100 gallons; added about 30 gallons yeast; total, 2500 gallons; presses added to must.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
24	..	..	..	Pressed 1 ton at 23½°-62° and added.
7	13	76	8	Pumped through cooler for ½ hr.
17	8	83	5	
3	..	..	..	Cooled 5 hrs. 30m. to 77°.
21	4.5	81	3.5	Going well.
2	6	80	(–1.5)	Added 300 gallons at 19.5°-64°.
5	4.5	82	1.5	Cooled 2 hrs. 30m. to 79°.
17	2	81	2.5	Going gently.
24	—0	84	2	Quite dry but going still.
120 hrs. or 5 d. 2 d. finish.				Average loss of sugar per 24 hrs., from 4.2° to 4.4°.
7 days.	max. temp. 84°		21°	Total cooling, 8 hrs.

At times it may happen that a white must shows signs of incipient fermentation after or during defecation. This is due either to insufficient sulfur or to unnecessarily prolonged settling in sump or tank. When it is noticed in the sump immediate action should be taken and the pure yeast will eventually prevail in the fermentation; at least, the character of the resulting fermentation justifies that belief because of its striking similarity to those in which the pure yeast is in control. One instance of such a "runaway" fermentation may serve to illustrate the point in question and Table 26 is therefore given on the next page.

It is evident from the nature of this fermentation that the exclusion of air and the presence of sulfurous acid caused a characteristic evenness in the daily loss of sugar after the first day, although such conditions prolonged the finish. The pure yeast, being accustomed to sulfur, may be presumed to have prevailed in the fermentative action after the first day, judging from the appearance of the low and dense froth, which generally accompanies the activity of pure yeast. The initial coarse, big froth, and the violent action, together with the loss of 6° of sugar in 19 hours, show that the beginning of the fermentation was directed by yeast other than the pure yeast. The long finish and the dropping temperature indicate a somewhat weakened fermentative power due to lack of oxygen. An aeration toward the end would have materially quickened the finish and raised or at least maintained the temperature at the end. The average loss of sugar (3.24°) shows this to be a fairly active fermentation, although it was never violent except in the start. The cooling was insufficient for a *cool* fermentation, but under the conditions of lack of air and presence of sulfur, which somewhat retarded the development of the yeast action, it seems to have been enough. In such cases the temperature does not generally rise as high or

TABLE 26.

White Must. Sugar, 22°; temperature, 60° F.

Crushed and pressed for two days into sulfured sump and then let down into sulfured tank for defecation; after 40 hours pumped up into a fermenting tank; showed signs of fermentation; difficult pumping on account of gas; **sulfur fermenting tank and use spray at end of hose** and spray must into tank to check action of "wild" yeast if possible; 2 hours later added 8 gallons pure yeast; total, 850 gallons.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
7	19	70	3	Coarse froth and violent.
12	16	74	3	Solid white cap of fine
24	11	83	5	foam; restrained ferm.
10	9	84	2	Cooled 1 hr. 40m. to 77°.
14	7.5	79	1.5	
24	5	83	2.5	Fine appearance and
24	2	86	3	quiet fermentation.
24	+0	87	2	Good froth.
24	—0	86	..	Dry but going still.
163 hrs. or 6 d. 19 hrs. 3 d.	finish till quiet.			Average loss of sugar per 24 hrs., 3.24°.
9 d. 19 hrs.	max. temp. 87°		22°	Total cooling, 1 hr. 40 m. (insufficient).

as quickly as where the vigor of the yeast and its growth are not restrained or checked by lack of air and presence of sulfurous acid. In these "runaway" fermentations the pure yeast might also be more abundantly added, and this was done in other cases with good results, but in any event the sulfur treatment at the start makes aeration toward the end quite necessary. Since, therefore, this extra work is rather annoying, such happenings should

be guarded against by proper sulfuring and quicker manipulations. It may possibly be doubted that this fermentation was the doing of pure yeast, and the conclusions are drawn only from the appearance of the action, since positive microscopic proof is of course lacking. Prevention is here, as elsewhere, better than cure. Such cases are, however, likely to happen to anyone, and mention is therefore made of such an occurrence. Even this wine has turned out to be a pleasant and smooth article at the present day, though fermentations of lower sugar and cooler temperature seem to produce wines that are still more agreeable to drink.

Another lot of must of the same variety of grapes was fermented at the same time. This was handled more promptly, being worked up in less time and defecated for only 29 hours, and the must remained quiet and took 24 hours to start. It showed 21° sugar and was 58° in temperature. When down to about 17° sugar another lot was added that had 20½° sugar and 64° F., and a day later a smaller lot with 6° sugar and 78° F. was also added, together with 2 gals. pure yeast to make up the required 1% yeast starter. It proved to be a steady and strong fermentation of a quiet character whose average loss of sugar per day was only 1.95°. A little stronger sulfur fumes were used to prevent a recurrence of the above spontaneous start. The maximum temperature was 82° and no cooling was necessary. The duration was longer than in the previous case, which may have been due to the additions after the fermentation had started. These also lowered the temperature; and besides, the first addition had no aeration, which would tend to check the development of the yeast growth and activity. But in the previous case the air was practically excluded by pumping the must into a sulfured tank, which in reality gave the sulfur a more prominent part in

that fermentation. We seem to have in it a proof of the effect of sulfur on the must, heretofore presented, namely, that it directs the yeast cells to confine themselves to their work rather than to increase in numbers. The result was a more prompt fermentation, while in the latter case the second addition carried with it also a large amount of developed yeast which had passed its highest stage of vigor (6° sugar). There seems to have been a clash between young and old yeast, so to speak, and this total large amount may not have had sufficient nutriment in the must to do the work quickly. Hence the longer duration of 10½ days with a finish of 3 days.

Mention was made elsewhere of the unsatisfactory results obtained from imported German yeast. At the beginning of a vintage there was a delay in the arrival of our usual supply of Champagne yeast, and an offer from a friend of some imported yeast was therefore accepted. It was socalled Zeltinger or Moselle yeast and was expected to do some extra fine work. Here was a chance to try the reputed characteristic of such yeast of imparting Moselle quality to the wine so made. It proved, however, to be unequal to the task of fermenting our heavy California musts under all the conditions imposed upon it. Delicate and sensitive in nature, it seemed to resent both sulfuring and cooling and was slow to recover from either treatment. It was also easily influenced by weather conditions, that is, it worked well only in good weather and lagged with a lower temperature. Finally, it admitted acetic ferments to the tub in which it was kept alongside of the more reliable Champagne yeast, which remained sound, and it had to be discarded altogether. Our conclusion was that it lacked vigor and hence fermentative power. In only one instance out of six did its action show any promptness and this occurred under perfect weather conditions, the days

TABLE 27.

White Must. Sugar, 21°; temperature, 63° F.

Crushed, pressed into sulfured sump; settled for 24 hours; also used 8 oz. bisulfite; made up in two lots, the second of which was **aerated** with rose nozzle over sump for **15 minutes**; first lot pumped into ferm. tank with spray; total, 800 gallons; added 12 gallons **Zeltinger** yeast.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
24	19	69	2	Violent start and big
12	16	76	3	bubbles.
10	14	79	2	Cooled 2½ hrs. to 70°.
14	11.5	74	2.5	
24	9	76	2.5	Rainy weather.
24	7	77	2	Cool days.
24	5	78	2	Cool days.
24	3	80	2	Cool days.
24	1	81	2	Big, fluffy froth.
24	+0	81	1	Big, fluffy froth.
24	+0	81	..	
12	—0	80	..	Quite dry to taste.
240 hrs. or 10 d. 36 hrs. finish.				Average loss of sugar per 24 hrs., 2.10°.
11 d. 12 hrs. max. temp. 81° average temp. 77.6°			21°	Total cooling, 2½ hrs.

and nights being equable and pleasant. This one fermentation lasted seven days, while the others consumed eleven to fifteen days. To illustrate the comparison of this Zeltinger yeast with the Champagne yeast let us take the concurrent fermentations of the same white must, one lot having the former and the other the latter for a starter. The first lot given in Table 27 started with German yeast, had 1° more sugar and was 2° higher in

temperature, while the second lot, as noted in Table 28, was started with Champagne yeast. This difference in sugar and temperature necessitated a longer cooling, but the maximum temperature in both cases was the same (81°).

This fermentation started with some violence, but subsided soon after and might be termed a strong one, except that it lacked the intensity of those started by the Champagne yeast, as seen in the low and dense froth of the latter.

Now let us turn to the fermentation of the same must but started with Champagne or Burgundy yeast from the University. It will be noticed that in both cases an excess of yeast was used, this being 1½% in the one just considered and 2⅓% in the following one. We have also open aeration in Table 27, because it was thought advisable to aid the imported yeast as much as possible in development. By contrast there is also a larger amount of bisulfite (19 oz.) in the second fermentation than in the first (8 oz.) just given. In spite of such conditions the average loss of sugar per day was only 2.1° with Zeltinger yeast but 2.82° with the Burgundy yeast.

We have here again the difference in the starts due to the application and omission of aeration, the first being violent and the other gentle; and also the effect of the sulfur is visible in the greater activity of the yeast in the second case soon after the start. As to the difference in duration, the larger amount of must in the previous case and its higher sugar would naturally consume more time, but such difference should rather be gauged by the average loss of sugar per day, because that indicates the fermentative activity of the yeast and reveals the true cause of the longer duration in the previous case.

These two lots were put together soon after they were through because of lack of cooperage, a circumstance somewhat to be

TABLE 28.

White Must (same kind). Sugar, 20°; temperature, 61°.

Crushed and pressed into sulfured sump; also used 19 oz. bisulfite in 4 oz. doses in press and sump, being compelled to hold must on account of lack of cooperage; defecated 46 hours in sump; well settled and clear; no open aeration but used spray when pumping into fermenting tank; total, 600 gallons; added 14 gallons Burgundy yeast.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
38	19	64	1	Gentle start and dense froth.
24	14	74	5	Cool weather.
24	8	80	6	Intense but not violent fermentation.
3	7.5	81	0.5	Cooled 1 hr. 40 m. to 73°.
21	4.5	77	3	
24	2	78	2.5	Going well with low
24	+0	80	2	froth.
12	—0	80	..	Dry to taste.
170 hrs. or 7 d. 2 hrs. 24 hrs. finish.				Average loss of sugar per 24 hrs., 2.82°.
8 d. 2 hrs. max. temp. 81° average temp. 76.75°			20°	Total cooling, 1 hr. 40 m.

regretted, since it was much to be desired to observe the later development of these two wines. In a few months it showed up bright and clear, and its analysis gave the following figures:

Alcohol .....12.74% by volume.
Free acid..... 0.43 gr. per 100 c. c. or 4.3 pro mille.
Volatile acid.. 0.053 gr. per 100 c. c. or .53 pro mille.
Grape sugar .. 0.07 gr. per 100 c. c. or .7 pro mille.

The claim that pure yeast yields more alcohol and cool fermentations precipitate more tartaric acid is again sustained quite well. The mere trace of sugar is probably due to the sluggishness of the Zeltinger yeast, but is not to be feared in view of the low volatile acid and the high alcohol.

Two more concurrent fermentations are now presented with the idea of showing the effect of temperature on the activity of the same imported yeast. The first showed an average temperature of nearly 75° F. and the second 77° F., the respective maximum temperatures being 79° and 84°. The higher temperature seemed to have a better effect on the fermentation in both its character and its duration. The extreme sluggishness in the first case is hard to explain and its contamination by acetic ferments still more so. For, the fermentations given in Tables 27 and 28 were started with the same yeast after the fermentations had been started that we are now about to consider. In these there was a very long after fermentation of four weeks, an occurrence that never happened with the Champagne yeast, and not sufficient precautions were taken to exclude the air during that period. The analysis of the two lots together is as follows:

Alcohol .....13.14% by volume.
Free acid..... 0.6 gr. per 100 c. c. or 6 pro mille.
Volatile acid.. 0.127 gr. per 100 c. c or 1.27 pro mille.
Grape sugar .. 0.18 gr. per 100 c. c. or 1.8 pro mille.

Table 29.

White Must. Sugar, 22°; temperature, 64° F.

Crushed and pressed into sulfured sump; defecated in sump for 14 and 18 hours, also added 10 oz. bisulfite; pumped into fermenting tank with spray at end; a small lot of grapes fermented on pomace for 40 hours and must added to tank; total, 1300 gallons; added 20 gallons **Zeltinger** yeast in all.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
24	..	no record	..	Boiling over on top and 100 gals. removed and used as starter for fermentation given below.
12	15.5	79	6.5	Cooled 1 hour to 75° (9 p. m.)
12	14	78	1.5	Violent and fluffy fermentation.
6	..	..	..	Cooled 3¼ hrs. to 71°.
18	11.5	73	2.5	Quieted down.
8	11	74	0.5	Cooled 3 hrs. to 69°.
16	10.5	71	0.5	Going well with fairly dense froth.
24	9	72	1.5	*Rainy and cool weather.*
24	8	73	1	Going slowly with big froth again.
24	6.5	73	1.5	Going slowly with big froth again.
24	5.5	74	1	
24	4	75	1.5	Froth 10 inches high.
24	3	76	1	
24	2	76	1	
24	1	76	1	
24	+0	76	1	Froth subsiding.
24	—0	76	..	
24	—0	..	..	Dry by taste.
360 hrs. or 15 d. 24 hrs. finish.				Average loss of sugar per 24 hrs., 1.46°.
16 days.	max. temp. 79° average temp. 74.8°		22°	Total cooling, 7¼ hrs.

TABLE 30.

White Must (same kind).. Sugar, 21°; temperature, 67° F.

Crushed and pressed into sulfured sump; also added 10 oz. bisulfite; defecated in sump for 19 hours; then pumped with spray into fermenting tank; pumped 100 gallons from preceding fermentation into this tank, addition being in full fermentation; no further yeast added; total, 450 gallons.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
24	15	79	6	Good, fine and fluffy froth.
26	12	84	3	Cooled 2 hrs. to 70°.
22	9.5	73	2.5	Good and firm froth.
24	6.5	75	3	*Rainy and cool weather.*
24	4	76	2.5	Going well.
24	2	77	2	
24	0.5	77	1.5	
24	—0	77	0.5	Dry by taste.
192 hrs. or 8 d.				Average loss of sugar per 24 hrs., 2.62°.
24 hrs. finish.				
9 days.	max. temp. 84°		21°	Total cooling, 2 hrs.
	average temp. 77.25°			

Under the supposition that the German yeast would work better in a low temperature an excessive cooling was resorted to in the first fermentation, but it is evident that this was detrimental to its vitality, which was in itself rather weak. In the second fermentation this was avoided and a much more satisfactory result was obtained. Possibly the addition of must fermented on the pomace may also have caused some difficulty in

the assimilation by the yeast of the nutriment necessary for its life and development. However faulty the operation may be considered, it will serve as a valuable illustration and lesson of the necessity of knowing the character of the yeast with which one has to deal. This German yeast is evidently not an adequate starter for the musts of our state, except, perhaps, when they resemble the German musts and are low in sugar and high in acid. It did fairly well in the second case and better yet in another fermentation which appears in the next table, but a rough and practical estimate of its value is derived from the fact that it is sensitive and lacks the sturdy vigor of the Burgundy yeast. A fermentation that shows a daily loss of sugar of only 1.46° indicates that the fermentative power of the yeast is entirely insufficient for our vintages, for the danger from contamination under our warm weather conditions must be continually guarded against if we want to avoid the results as shown in the analysis of this wine. While the alcohol is remarkably high again and may help the wine considerably in keeping, the relative amounts of volatile acid and sugar exhibit a similar condition as the drawn trigger on a loaded gun –something may pop at any time unless we handle things very carefully.

What this German yeast can do under good weather conditions will be seen in Table 31, which gives the fermentation of a must fuller in body. The analysis of the wine was as follows:

Alcohol, 13.34%; free acid, 0.46%; volatile acid, 0.057%.

The yeast was no doubt better sustained in this case by the greater amount of nutriment in the must. The duration was comparatively short and the general character of the fermentation showed much vigor and promptness. The cooling also was long, considering the quantity of must fermented, and did not apparently check the activity of the yeast. It was pre-eminently a lucky combination of conditions.

The proper succession of the fermentations given in the four tables with Zeltinger yeast as they occurred during the vintage was as follows:

(1) Table 31 with good weather conditions.
(2) Tables 29 and 30 with partly rainy and cool weather.
(3) Table 27 with rainy and cool weather, same as (2).

TABLE 31.

White Must. Sugar, 22° and 23°; temperature, 62° F.

Crushed and pressed into sulfured sump in two lots, both defecated in sumps for 23 hours; added 11 oz. bisulfite in all; pumped out with spray at end into fermenting tank and added 6 gallons Zeltinger yeast; total, 900 gallons; fermented in lower and cooler cellar; good weather.

Hours from start	Sugar	Temperature	Sugar lost	Remarks
19	18	70	4	Good, dense froth.
24	12	82	6	
4	11	83	1	Cooled 4½ hrs. to 71°.
20	7	76	4	Boiling up with little froth.
10	6	78	1	Cooled 1¼ hrs. to 75°.
14	4	77	2	Boiling still.
7	3.5	79	0.5	Cooled 1 hr. to 75°.
17	2	78	1.5	Boiling with froth forming.
24	—0	80	2	Quite dry to taste.
139 hrs. or 5 d. 19 hrs. 29 hrs. finish.				Average loss of sugar per 24 hrs., 3.8°.
7 days.	max. temp. 83° average temp. 78°		22°	Total cooling, 6¾ hrs.

The variability of the activity of the yeast in these four fermentations may best be seen in a general view of the principal prevailing conditions, excepting the composition of the musts.

In all these cases there was the usual sulfuring of the covered sumps for defecating the must, No. 31 being settled for 23 hours, No. 29 for 14 and 18 hours, No. 30 for 19 hours, and No. 27 for 24 hours. Aside from the variation in the composition of the musts, which is undoubtedly an important item for the fermentative action of the yeast, the general conclusion may be drawn that this German yeast required, after all, a higher temperature for its vitality, as well as good weather conditions for its sustained activity. This may be seen in the average and maximum temperatures of the last table. The amounts of yeast and bisulfite, and their proportion to the quantity of fermentable must, which also affect the duration, may serve again as reminders of the observations heretofore recorded under the various chapters.

TABLE 32.

Table	Gallons	Sugar	Temp.	Bisulfite	Yeast	Average Temp.	Max. Temp.	Aeration	Cooling	Duration
31	900	22°	62°	11 oz.	2⅔%	78°	83°	ordinary	6¾ hrs.	7 d.
29	1300	22°	64°	10 oz.	1½%	74.8°	79°	ordinary	7¼ hrs.	16 d.
30	450	21°	67°	10 oz.	100 gals. from No. 29	77.25°	84°	ordinary	2 hrs.	9 d.
27	800	21°	63°	8 oz.	1½%	77.6°	81°	15 m. open; also ordinary.	2½ hrs.	11½ d.

Such experiments lay stress on the necessity of having some knowledge regarding the character of the yeast that we use. The German yeast was rejected because of its sensitiveness to temper-

ature and sulfuring, and on account of its lack of vigor in resisting other ferments. It is, therefore, not nearly as reliable as the sturdy Champagne yeast, which under varying conditions has always done good work.

As to the mooted question whether pure yeast, or yeast cultures from famous wine districts, will transmit or impart the character of those wines to our native musts, it seems as if the wish were father of the thought. There is unquestionably a certain individuality in the yeast cells that was acquired through their abode in a certain locality, and this may possibly slightly influence the character of the resulting wines, but it will hardly alter the real nature of our musts. A vigorous yeast, like the Burgundy yeast, accomplishes good results mainly by its more efficient and thorough work. In other words, it is a selected and developed yeast, just as grain seed is rendered more productive by proper selection and cultivation—a bit of scientific truth which the farmers were slow to believe, but are now diligently applying to their own work. For practical purposes, therefore, we should have a yeast that will produce uniform fermentations, and any variety that shows such variableness as the German yeast can not be a safe and reliable starter for fermentations.

GLIMPSES OF CASTLE ROCK VINEYARD.

COOPER GRAVURE
SAN FRANCISCO

CHAPTER VII.

CONCLUSION.

> "Wine of itself never injured any man; it's the man that abuses the wine, and wine like any other sensible creature fights back when it finds that it is being mistreated." (Saying of an old Scotch divine.) —"Beverages, Past and Present," by E. R. Emerson.

It seems hard to convince the American public that the sanest policy in behalf of *true temperance* consists of the reasonable use of light dry wines at meal-time. *Total* abstinence is not a natural condition for the average human being, for, that means abstaining from *all* stimulants, such as coffee, tea, tobacco, besides alcoholic beverages. Under the plea of sickness patent medicines have been resorted to by many a sanctimonious hypocrite to satisfy his perfectly natural craving for a stimulant now and then. Any unbiased observer can notice the deleterious effect of coffee and tea on persons habitually and excessively addicted to their use. However much we may want the wine industry to assume larger proportions, we can not afford to back and foster it if that advancement means also an increase of intemperance. The abuse of wine is as bad as the abuse of any other alcoholic beverage—it leads to an early and deplorable death; and no man should be encouraged to take such a course. Only in rare instances, however, can the blame be laid at the door of the maker of light dry wines. For, moderately taken these fill the cup that exhilarates but does not inebriate. Let us as winemen decry and discourage intoxication wherever and

whenever found! It is truly to our own interest to do so at all times and places. To accomplish that people should be encouraged to substitute light wines for distilled liquor, and the quality of our wines should be made so excellent and attractive that such substitution will be readily accepted. The best effort that the winemen can, therefore, possibly make in behalf of temperance and their own business, is to improve the quality of their product so that it will be preferred to the more harmful and intoxicating liquors.

Dr. Charles W. Eliot, the eminent educator and ex-president of Harvard College, was asked to what he ascribed his remarkable mental and physical vigor at the age of seventy-seven, and he replied: "Moderation in eating, a full allowance of sleep, and no *regular* use of any stimulant whatever." He further stated that his capacity for work was largely due to "avoiding all sorts of luxury and the constant use of any drug, such as alcohol, coffee, tea and tobacco".

It is not the *constant* use of even light wines that can be conscientiously advocated in the cause of temperance of a better kind than total abstinence, but rather the custom of drinking them with meals *whenever* there is need of a little stimulating exhilaration after the worries and the fatigue of the day.

Prohibition does not prevent the use of intoxicants. In socalled "dry" states the liquor consumption has no small dimensions. Secret drinking leads to intemperance sooner than the social glass. The great South now has a problem that is ten times worse than drunkenness, namely, the use of cocaine among the negroes of the states where prohibition prevails. Its effects are said to be far more appalling than those of alcohol.

In London the "no drink between meals" movement has grown remarkably popular and is reported to have made many

of its followers total abstainers. This only goes to show that the use of wines at meals has a very chastening effect on both mind and body. Under normal conditions, when the body is healthy and social and business cares make no excessive demands on its vitality, *pure* water is perhaps the ideal beverage; but most human lives are not cast amid such well regulated surroundings, nor are we quite sure of the *purity* of the water that is set before us. Quite true that we generally do not drink enough water for our system, but let the prohibition cranks look to it that such water does not contain billions of disease bacteria. For, this innocent (?) beverage also holds its annual harvest of human life by directly putting into the human body the death dealing germs of typhoid, cholera and other fatal diseases.

The constant use of heavy sweet wines and strong liquors must in the end clog the circulation of the body and prevent the normal waste and supply of tissues which make up good health. That means disease with much unnecessary suffering, and a premature death. The preservation of health is a duty which everyone owes to his family and to society at large. The longer we can remain vigorous in mind and body and useful to the community, the more are we entitled to the benefits of social order and to the gifts of fortune. Such rational aims are assisted by the moderate use of light dry wines, since their very purpose is to aid digestion and make us smile and talk while we eat and nourish ourselves, so that Macbeth's toast to his guests may come true:

"Now good digestion wait on appetite
And health on both."

The introduction and use of light beers have also done a great deal for the cause of true temperance, and I have no fault to find with anyone who drinks them between or at meals. They are healthful in moderation and mildly stimulating, though they have

not the animating effect of dry wines. It would be a great help to the industry if light wines could be dispensed in the saloons and winerooms at the same price and directly from the barrel, with a similar pressure of carbonic acid gas attached to it when drawing therefrom; because one is often served from a stale bottle that has probably been open for a day or longer.

A wise experience and sane judgment have led to the custom in Europe of adopting the use of light wines and beers as the most sensible plan for the prevention of intemperance. There also the women of all classes drink these beverages openly and yet remain honorable members of society. In fact, it were better if our American women accustom themselves to the use of light wines, so that they would find no satisfaction in stronger drinks. We men need the co-operation here, as elsewhere, of fairminded and brave women, who realize that the safest guidance they can give their sons and daughters to keep them from intemperate habits lies in the use of light wines with their meals. The foolish and pernicious custom of serving cocktails *before* dinner, and nothing but water of doubtful purity during its courses, is at variance with all laws of hygiene and should be abolished for the cause of true temperance.

While the industry is indebted to a great extent for its continued progress to a few large enterprises where quantity *and* quality go hand in hand, its backbone will always be in the rank and file of the men engaged in this line of work. With a natural love for the work many small winemakers are more apt to give their personal attention to the details of the care of wines. This means that they are working *and* thinking at the same time, and among them there will probably be found the *practical idealists* needed to uphold a high standard for the quality of our California wines. "The master's eye is his ready servant", says a Spanish

proverb, and this is especially applicable to the making of fine wines, for they are not as a rule made in large quantities. There is therefore always a good chance for the smaller cellar in the right locality to become distinguished for quality as well as purity. Fortunate is he who under such conditions is able to discontinue making bulk wines for the dealers and can market his product under his own brand. It is a difficult task, but it is the only way to get some satisfaction out of the hard work done. This individual effort for quality will in the end enable us to compete with the products of Europe.

Twenty years ago I was of the opinion, and maintain it today, that our California wines suffer by comparison with European products, not entirely because they were then or are today inferior in quality—which was then perhaps more often the case than it is now—but rather because we gave them the very names of the grapes from which they were derived. They were, and for that matter they are today, I am sorry to say, called Riesling, Hock, Gutedel, Sauterne, Burger, Cabernet, Zinfandel, Burgundy, and what not else. This strange folly, though meant for a classification, adds nothing to the value of the wine in the mind of the average customer; whereas distinctive names backed up by real and easily discoverable quality would not only impress themselves on the customer's memory more permanently, but would also give a vineyard or cellar a distinct and permanent reputation. What has proved to be expedient and effective in Europe can be made just as expedient and effective here in California. In relation to this topic a quotation from the work mentioned at the head of this chapter is quite pertinent:

"The want of foresight on the part of the early winemakers in the East in not giving their wines proper and distinctive names should have been a lesson to the Californians, but, like

many other matters of this nature, the warning was not heeded, and the result is that the oenological nomenclature of America—or at least of the United States—is only remarkable for its almost entire lack of originality. Unlike France, Germany, Spain, and other wine-producing countries, where characteristic and symbolical names were applied or given to the product of their vineyards, the American vineyardists have never had the temerity to assume their proper place among the brethren in the craft. * * * They (our wines) have to bear comparisons that are at the very outset unfair to them. Their merit and real value are lost at once in the thoughts of the drinker when he is told their names, for no matter how fairminded he may be, the name will bring to him thoughts of the original, and unconsciously there will ensue at once a comparison, not as to the merits of the wine, but upon the line suggested by the title, which at once removes all chances of a free, unbiased judgment. * * *'' (Vol. II, pp. 453-4.)

It is, therefore, to be hoped that in time this wise custom of original names will be followed more and more. Even now it is being carried out by those who take a justifiable pride in their good products, and such a plan embodies a decided protection against imitators. What difference does it make if we do not openly advertise on the bottle the variety of the grapes from which the wine was made? That is rightfully the secret of the winemaker who mixes his varieties into harmonious blends both during the vintage and subsequently in the cellar. For, with all these new methods herein recommended, there still remains the art of blending, which requires as much care and skill again as were employed in such winemaking. The foundation, however, should be laid well if we expect our house to stand the strain of storms, or to apply this to wines, if we want our wines to reach a sound and mellow maturity.

The methods discussed in this manual are within the reach of everyone who can command a fair supply of cold water. It is far better to have a cooler for the prevention than a pasteurizer for the correction of the defects and diseases of wines; for, with the latter we are likely to deprive the wine of its very life and essence. Though the tongue should be a good and reliable judge in all matters pertaining to the soundness and quality of the wine in question, yet an analysis made by a competent chemist will give the winemaker a better idea of its composition than our senses of sight, smell and taste can render. Especially is this true of the remnants of sugar not transformed into alcohol, most of such fractions being, however, negligible for practical purposes. Fulness of taste, for instance, though not always caused by sugar, would be an argument for its possible presence; and such sugar may cause trouble as it always forms a feeding ground for harmful bacteria. Likewise the volatile or acetic acid and its percentage furnishes valuable information regarding the future of the wine. Finally, alcoholic strength is quite an important item for the guidance of winemaking in successive vintages, especially if we are trying to make light wines. However skilful we may be with our senses and however close we may be able to get to the composition of a wine, a complete and truthful information can come only through a chemical analysis for determining the alcohol, acids and sugar, as well as by a microscopic examination for suspected disease germs. However clever we may imagine ourselves to be in the way of correcting faulty wines, it would seem to be more advisable to definitely ascertain the fault first before applying the remedy.

Inasmuch as pure yeast seems to produce more alcohol in conjunction with adequate cooling—which latter also effects lower acids—it may become necessary to re-establish a more normal

proportion between the alcohol and the acids by an earlier harvest. This tends to give us a better balanced and lighter wine that would still possess the aroma and smoothness developed by these methods. With such a prospect before us a wine of that character could possibly be bottled young and remain clear, retaining all the freshness of its youth which in a semi-tropical climate like ours is hard to preserve in wood. The accepted belief that mellowness comes with age is in danger of being overthrown and the fad of rendering white wines fresh by charging them slightly with carbonic acid gas is an innovation of doubtful benefit to the future of the wine industry. There is no doubt but what many of our wines should be bottled promptly when mature, or when from two to three years old, but as to bottling them in their first year—well, as our friend from Missouri says: You've got to show me!

The main points discussed in the preceding pages may be briefly summarized as follows:

The Conditions:	**The Results:**
(1) A vigorous, pure yeast.	(1) More alcohol and drier wines.
(2) The use of sulfur and bisulfite to prevent bacterial infection.	(2) Less danger from secondary fermentations.
(3) Cooling to preserve aroma and alcohol.	(3) Greater smoothness and quality
(4) Less sugar for light wines.	(4) Early brightness.
(5) Early racking and fining.	(5) Early maturity.
(6) 82°-84° maximum temperatures of fermentations.	(6) Good keeping qualities.

With all the good results accruing from such conditions, there is still the requirement of skill entering largely into the operations and methods herein suggested and demonstrated. The subsequent care of the product so made takes fully as much time and atten-

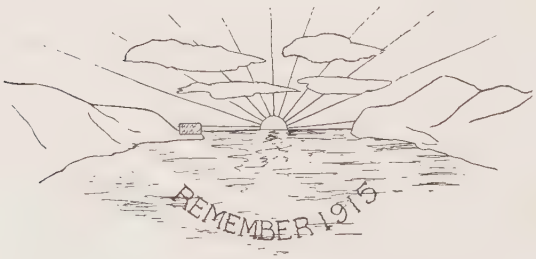
tion, but the wine is more stable and less liable to go wrong. Since such wines possess good keeping qualities there is no occasion to employ the tricks of the trade often used to correct badly made wines; for, *the wines so made are preeminently honest wines.*

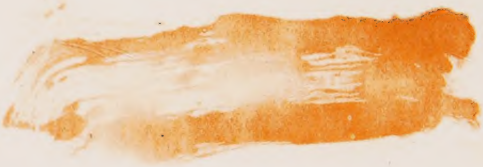
Competent critics may find this manual faulty and defective in parts, and also perhaps not as exhaustive of the matter in hand as may appear desirable from the point of view of applied science. It was the writer's intention to present only the main features of the subject, and to discuss and illustrate these more from the practical point of view. For his possible errors he pleads a lack of a thorough scientific training in this line of work; and if he had received such he would perhaps not now be engaged in the task of trying to unite the two elements of this industry, Science and Practice, for the greater end of progress and prosperity. It has seemed to him at times as if even active Error in search of truth leads to more tangible enlightenment than sedate and passive Learning in seclusion. It does not add to the sum of human happiness when *science* stays in the serene altitude of research pure and simple, while *practice* is plodding in the darkness of tradition and limited experience. Only in their union is revealed the true meaning of the former and the real strength of the latter.

The Panama Pacific Exposition of 1915 looms up in the distance. The resulting impetus given to every industry by that coming event will prove to be a great force in the general advancement of our state. Being located at the end of the occidental world and somewhat inaccessible from the great East, we have suffered from lack of population on the one hand and from arbitrary and inadequate transportation facilities on the other. The trials of the vineyardist and winemaker have been particu-

larly severe and discouraging, but with the aid of our State University and of the government agricultural stations, and with this opening of the world's commerce before us, we may confidently look forward to permanently better times. Much depends now upon individual and collective efforts for the further improvement of our wines.

A new era dawns for our state, and it seems worth while for every winemaker to put forth an extra effort for the production of wines of quality. We should show the whole world, then represented in our midst by critical commissioners, that California can produce high class wines that compare favorably with the best products of Europe. To further that purpose it is hoped that these pages may be of some service to all the progressive men engaged or interested in this line of work.





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